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RECENT THEORIES IN REGARD TO THE DETERMINATION OF SEX.

By Professor T. H. MORGAN,
BRYN MAWR COLLEGE.

IT was long believed that the sex of the embryo is determined at a relatively late stage in its development, and therefore it seemed probable that external factors must decide whether the embryo is to become a male or a female individual. Many views have been held as to what these external factors are, and from time to time hopes have been held out that it might be possible to regulate, by artificial means, the sex of the developing embryo.

In the last few years opinion has begun to turn in the opposite direction, and several attempts have been made to prove that the sex of the embryo is determined in the egg. That this must be the case in man seemed to be indicated by the fact that 'identical twins' are always of the same sex. There can be little doubt that such twins come from the same egg, and the presumption is strongly in favor of the view that they represent the separated first two cells of the segmenting egg. These twin embryos are enclosed in the same chorion, which further indicates that they have come from one egg. The 'ordinary twins' of man are no more like each other than are any other two children born at different times. The pair of ordinary twins often consists of a male and a female. Since the embryos that give rise to ordinary twins are subjected to practically the same conditions during their uterine life, and are often, as has been said, a male and a female in a pair, it follows that in man the external conditions that affect the egg, after it has left the ovary or after it has been fertilized, do not determine the sex. A similar and even more remarkable fact is known

in the case of the armadillo, *Tatusa hybrida* of Paraguay. The eight to eleven young of each birth are always of the same sex. This occurs also, it is said, in another species, *Tatusa novemcinta*. In the latter case it was found by Jehring that all the embryos of one birth are enveloped in a common chorion, although each has its own separate placenta. It is probable that these embryos are the product of a single egg that has become separated during the early stages of segmentation into as many parts as there are embryos produced. That separated blastomeres or cells are capable of giving rise to whole embryos has been demonstrated experimentally in recent years for a number of animals.

The following discovery also bears on the same question. A hymenopterous insect, a chalcid bee, *Encrytus fuscicollis*, lays one or two eggs in the egg of a caterpillar that is to become the host. The egg of the parasite develops inside the body of the young caterpillar, not into a single embryo, as is the rule, but into a chain of embryos. As many as a hundred embryos may come from the same egg, all united in a common amnion. It has been observed that the bees that emerge from the same caterpillar are frequently of the same sex. Thus in twenty-one observations the progeny was in fourteen cases all of the same sex. In the remaining seven cases both males and females appeared. In the former it is probable that only a single egg had been laid in the egg of the butterfly, and in the latter more than one egg may have been deposited.

One of the earliest and most important of the recent memoirs that have attempted to show that the sex of the individual is determined in the egg is that of Cuénot.* This paper deserves first place not only because in point of time it precedes the others to be mentioned, but also because the author has undertaken a considerable number of important experiments that bear on the problem of the determination of sex.

It had been claimed that when young caterpillars are poorly nourished they give rise to a larger number of males, and conversely, when well nourished to a great majority of females. The experiment was first carried out by Landois, and later confirmed by Giard, Treat and Gentry. On the other hand, Riley found that starved caterpillars, as well as those abundantly supplied with nourishment, give both male and female individuals with no greater disproportion in numbers than ordinarily exists. Other observers have recorded similar results. Furthermore, a number of investigators have shown that the sex of the young insect is already determined at the time when it emerges from the egg and even some time before that event. Brocadello's

* *Bulletin Scientifique de la France et de la Belgique*, XXXII., October, 1899.

observation is even more important. He discovered that there are large and small eggs laid by the silk-worm moth, and that the caterpillars emerging from the large eggs are, in the great majority of cases (88 to 95 per cent.), females, while those from the smaller eggs give a corresponding majority of males (88 to 92 per cent.). It is therefore clear that the difference in size corresponds to a difference in the sex of the embryos, and that with sufficient care it would be possible to separate the two sorts of eggs so completely that all of one kind would be females and of the other males. A similar result has been obtained by Joseph in another moth, *Ocneria dispar*. Cuénot states that he has been able to verify completely this statement of Joseph.

How can we explain the apparent contradiction between the results of Landois, Treat and Gentry, and those of Brocadello, Joseph and Cuénot? It is probable that in all cases the facts recorded are correct. Cuénot suggests that in the lots of caterpillars that were poorly nourished there was a large mortality of the young females, so that of those surviving there was a larger percentage of males. If we apply this same view to the case in which abundant feeding gives rise to more females we shall have to assume that here a larger percentage of males are eliminated, but it is not at all evident why this should be the case. Cuénot points out another possible source of error; namely, that in selecting the caterpillars for the experiment the larger ones may have been picked out to be given an abundant diet and the smaller ones for a meager diet. If this had been done consciously, or unconsciously, the results would not be due to the quality of the food, because the young caterpillars that were large were already females (having come from larger eggs), and those that were small were already males (having come from small eggs). It is clear, therefore, that all the early experiments must be repeated and the precaution taken to note the number of caterpillars at the beginning and at the end of the experiment, and the sex of those that die must, if possible, be determined. Care must also be taken that no selection of large and of small individuals takes place. Since, however, it has been so clearly shown by Brocadello and by Cuénot that large eggs become females and small eggs males, it will be desirable in repeating the experiments to take this fact into account, and to attempt to discover if the potentialities of the large and of the small eggs can be changed by external conditions. Here we have a new field for experimental work that will yield results of great interest. The lines are now so definitely drawn, and it is clearly so important to settle this question on as many forms as possible, that it is much to be hoped that in the near future many workers will turn their attention to this important subject.

Cuénot's experiments on certain flies, belonging to four different genera, are of especial interest. In this group also it had been claimed

by Lowne that individuals from the large maggots that have been well nourished are nearly always females, while those from small maggots, poorly nourished, are usually males. Cuénot first determined, in the three genera used in his experiments, that normally the number of males and of females is about the same. The results of his experiments, in which the maggots were well fed, were as follows—in *Lucilia cæsar* 49.27 per cent. of females; in *Calliphora vomitoria* 51.02 per cent. of females; and in *Sarcophaga carnaria* 51.62 per cent. of females. It is obvious that the presence of an abundance of food did not produce an excess of females. In another experiment in which the maggots received as small a quantity of food as possible there was great mortality and the pupæ were of diminutive size. The results were as follows—*Lucilia cæsar* 57.92 per cent. of females; *Calliphora vomitoria* 57.92 per cent. of females; and *Curtonerva pabulorum* 26 females and 17 males. It is even more evident from the results of this experiment that starving does not have the effect of producing an increase in the number of males. Several variations of these experiments were made, but the results were always the same. Cuénot also tried to find out if the amount of food taken by the individual during its growth has any effect on the *kinds of eggs* that are produced. The larvæ of *Calliphora vomitoria* were starved from their birth until they pupated. They gave rise to twelve males and five females, whose size was scarcely half that of the normal individuals. These dwarf flies, confined in a cage with sweetened water and meat, laid twenty times. The larvæ that hatched were kept in a well-nourished condition, and gave rise to 359 females and 353 males. The results show that the amount of food supplied to the young maggots had no effect upon the relative number of male and female eggs that they produced. It is true that these animals, when poorly nourished, gave rise to only a few eggs, but the relative number of eggs that became male or female remained the same.

Among the earliest experiments that were carried out to show whether the sex of the individual could be determined by external conditions were those of Born in 1881, and of Yung in 1883 and 1885. Born tried to show that more male frogs develop when the fluid containing the fertilizing spermatozoa is more concentrated, but this conclusion has been shown to be wrong. Born also fed the tadpoles of *Rana temporaria* on a rich diet consisting of water plants and of the flesh of frogs and of tadpoles. A large percentage of females developed which Born attributed to the abundance of food. It was shown, however, by Pflüger in the following year, 1882, that Born's conclusion was erroneous, because, even under normal conditions, female frogs are more numerous. Pflüger found that the normal proportions of females to males is often as high as five to one; and this corresponds also to the

proportion sometimes obtained when tadpoles are reared from eggs artificially fertilized.

Yung found that females of *Rana esculenta* are twice as numerous as males, while Cuénot found, on the contrary, in a different locality that there were more males than females.* It is not known whether this disproportion in the sexes is due to the greater mortality of one sex, or whether there are more eggs of one kind than of the other. The results appear to indicate, however, that external conditions do not have a determining influence on sex, and it seems not improbable, although not completely established, that there may be greater mortality among the male tadpoles than among the females in some species and in certain localities.

Cuénot made a few experiments with the eggs of *Rana temporaria*. He points out that his results are open to the same grave criticism as are those of his predecessors in that he did not determine the sex of those that died. In one experiment in which the tadpoles were given an abundant supply of vegetable food they suffered greatly from crowding and from insufficient aeration of the water. Their development was retarded and they remained small. Of the 26 frogs that metamorphosed all were females. In another similar experiment there were 3 females and 4 males. In a third experiment the tadpoles were placed in a large aquarium supplied with cold, running water. No food was given, and the tails of the tadpoles were frequently amputated in order to prolong the larval period. There emerged 57 young frogs, of which 33 were females, 29 males, and one hermaphrodite.

In a fourth experiment the tadpoles were separated into three lots. The first were given a vegetarian diet; the second were given only animal food; and the third were put into a large aquarium whose floor was covered with mud, but no food was present. The tadpoles that died were no doubt eaten by their companions and thus a certain amount of food was probably obtained.

The first and the second lots developed at the same rate, but the tadpoles did not reach a large size owing to the small dimensions of the aquarium. They became frogs after two months. Those of the third lot on the contrary were retarded in their development; they remained small and began to die from hunger after the third month. They were then given animal food; they grew rapidly and metamorphosed a month later, *i. e.*, four months after hatching. The frogs were of small size and showed signs of having been poorly nourished. Of the 35 survivors of this third lot 23 were females and 12 were males. Of the 36 survivors of the second lot (with animal diet) there were 14 females and 22 males. Of the 108 survivors of the first lot (vegetarian

* Boulenger also found in *Pelodytes*, *Pelobates* and *Bufo* an excess of adult males.

fed) there were 51 females and 57 males (and 8 not differentiated). The proportionate number of females to males in all the tadpoles reared in these experiments is not different from that which Cuénot determined in nature. He concludes from his results that the sex of the frog is not influenced by the external conditions (especially of food) to which the tadpoles are subjected.

Pigeons have also furnished some interesting facts in regard to problem of sex. From the time of Aristotle it has been recognized that of the two eggs laid in each batch one generally produces a male and the other a female. Nevertheless numerous exceptions have been recorded in which both individuals were of the same sex. Cuénot himself found in eight sets that in two instances there were two males; in two instances there were two females, and in five instances there was a male and a female.* It has been claimed moreover, and the tradition also goes back to the time of Aristotle, that the first egg laid gives rise to a male and the second to the female. Flourens confirmed this fact for eleven sets, and Cuénot found the same result. The meaning of this is obscure, for it may be that a male egg is first set free, or that the conditions to which the first egg that is laid is subjected are such that it becomes a male. The former interpretation may appear to be the more probable, but it is not conclusively established by the facts.

Although many statistics have been brought together in regard to the determination of sex in man and in other mammals there is no convincing evidence showing that external factors determine the sex of the embryo; and, as has been pointed out, there is strong evidence pointing in the opposite direction.

If we turn now to some of the lower animals we shall find that there are a few indisputable cases in which it has been shown that the sex of the individual is predetermined in the egg. It was discovered by Korschelt that two kinds of eggs are produced by a small worm, *Dinophilus apatris,* and that the larger eggs develop, after fertilization, into females and the smaller into males. The females are about 1.2 mm. long, while the males are only 0.04 mm. long. The males are degenerate in structure; they are less numerous than the females, and live only ten days, whereas the females live a month or more.

A similar difference in the size of the eggs that produce males and females is found in certain rotifers, in *Hydatina senta* for example. In this species there are three kinds of females distinguished by the different kinds of eggs that they lay. One lays large eggs which without fertilization produce females. Another lays small eggs, less rich in yolk than the last, and these eggs, also without being fertilized,

* There is here probably a misprint since 2 + 2 + 5 equal nine.

produce *males*. A third kind of female produces the winter eggs, which are fertilized by the males and give rise to females. In this rotifer the sex of the egg is determined while the egg is still in the ovary, and Nussbaum has made the important discovery that the amount of nourishment taken by a young female, between the time of her emergence from the egg and the deposition of her first egg, determines which kind of eggs she will subsequently produce. If she has been well nourished in this interval she produces eggs that become females, but if poorly nourished she produces male eggs. After the eggs have been once formed no subsequent change of food or of temperature can alter the kind of eggs that are produced. It has not been determined why some females produce parthenogenetic eggs and other females winter eggs that are to be fertilized. Nussbaum thinks that the effect of an early union with a male, combined with insufficient nourishment during the first hours of free life, determine that winter eggs are to be produced.

Amongst crustaceans and insects there are several instances known in which the sex of the individual appears to be connected with certain kinds of eggs. The water fleas, or daphnids, produce during the summer small parthenogenetic eggs with a thin shell which develop into parthenogenetic females,* but under certain conditions males and females appear. The females produce large winter eggs which are fertilized and produce in the following year only female daphnids which start the parthenogenetic summer broods. The sex of the winter eggs is probably determined in the ovary, since the eggs show their characteristic structure before they are set free. The appearance of the male and female generation is supposed to be connected with the change in temperature, or more probably with a change in the amount of food. Under these conditions, as has just been said, eggs that produce males and females are formed. Here it would appear that an external condition determines the appearance of the male and of a different kind of female.

Similar facts are known for the aphids, or plant-lice. If conditions are favorable, *i. e.*, if they are kept warm and have an abundance of succulent food, they continue indefinitely producing wingless parthenogenetic females. But if the food becomes scarce or dry, then winged males and females arise from the parthenogenetic eggs; these unite, and the fertilized winter eggs are laid. From these eggs the wingless parthenognetic females arise in the following spring.

The life history of *Phyloxera vitifolii*, which is parasitic on the

* Lenssen claims that the parthenogenetic female eggs do not give off a polar body, and that the male eggs give off only a single polar body. Whether this difference may have any relation to the sex of the individual will be discussed later.

roots of the grape, is as follows: A series of parthenogenetic wingless females succeed each other, until at the end of June the last generation of these produces, parthenogenetically, winged females that are capable of migrating. These also produce parthenogenetic eggs of two kinds, small ones from which winged males develop, and larger ones from which winged females arise.* Union of the sexes now takes place and each female lays one egg which gives rise in the following spring to the parthenogenetic wingless female that lives on the root of the grape vine.

We come now to the much discussed case of the hive bee. There are here three kinds of individuals: the queen which lays all the eggs; the workers, which are immature females and do not reproduce at all, and the drones or males which fertilize the eggs of the queen.

It has long been believed that when an egg of the queen is fertilized it gives rise to a female (either queen or worker according to the kind of food given to the young maggot), but if not fertilized the egg gives rise to a male. It has been generally assumed, in accordance with this belief, that all the eggs are alike and will produce males if they are not fertilized, but females if they are fertilized. It is known moreover that the cells of the comb in which the queen deposits the eggs that are to become males are different from the worker cells, and this fact is generally interpreted to mean that the queen is capable of determining the sex of her offspring by allowing or preventing the fertilization of the egg. The sperm which was received by the young queen at the time when she left the hive with a swarm is stored up in a special sac or receptacle with muscular walls and an outlet that opens near the oviducts. It is generally assumed that the queen squeezes out the sperm when an egg that is to be fertilized is laid, but does not do so when a male is to be produced. Some writers have marveled at this wonderful power, that seems almost akin to intelligence, by which the queen determines 'at will' the sex of her offspring, but this may give an entirely exaggerated idea of what takes place, for the act may be a very simple reflex. It has been shown by Drory that if the queen is supplied with an artificial comb containing only drone cells she may be forced to lay in them fertilized eggs that become workers. Conversely, if supplied with worker cells only she will sometimes lay unfertilized eggs in them. This has been interpreted to mean that there are really two kinds of eggs that are laid by the queen, male and female, and that only the latter are capable, as a rule, of being fertilized. On this assumption we should be forced to conclude either that the queen can determine which kind of egg is to be laid and places it in its proper cell, or that she has a knowledge

* The small eggs appear to be laid by the smaller winged individuals and the larger eggs by the larger individuals.

of which kind of egg she is about to lay next, and seeks the proper cell to deposit it in. There are, however, some further facts that show that the conditions may be more complicated than has been generally supposed.

It has been possible to introduce a virgin queen of an Italian stock into a hive containing workers and males of a German stock. These two kinds of bees are sufficiently different to be readily distinguished from each other. The Italian queen becomes fertilized by the German males. In consequence all the queens and workers that come from her eggs are hybrids, since they come from fertilized eggs, but the males or drones are nearly all of the same kind as the queen, which indicates that they have come from unfertilized eggs. Occasionally, however —and this is the point of special interest in the present connection— a few males appear that are hybrids, as Dzierzon long ago observed. Hence we must suppose that an egg has been fertilized, and despite this fact it has developed into a male. This conclusion may indicate, as Beard has recently claimed, that the sex of the egg must have been already determined, and was not altered by the accidental entrance of a spermatozoon.

In this connection it should be pointed out that Weismann and Petrunkewitsch found that out of 272 drone eggs that they studied there was one that had been fertilized. Whether it would have become a male or not, could not be determined; for it is said that the queen sometimes makes a mistake and deposits a worker egg in a drone cell. Indeed 'whole combs of drone cells may produce workers instead of drones.'

These are some of the principal facts that seem to show that the sex of the individual is predetermined in the egg. From the evidence Cuénot arrives at the following general conclusions: He thinks that in the great majority of animals the sex is determined in the egg and at latest when the egg is fertilized. In no instance, he claims, has it been shown that the sex of the individual can be determined later than fertilization. The classic examples, insects and frogs, in which it was supposed that external conditions acting on the later embryo determined the sex, have been shown to be capable of a different interpretation. It has been especially made clear, Cuénot claims, that a meager or an abundant supply of food has no influence on the determination of the sex of the embryo. He believes moreover that it is the egg and not the spermatozoon that determines the sex of the individual. In several insects, in *Dinophilus,* in pigeons, and in the winter eggs of aphids and of daphnids, this has been clearly shown to be the case. In other animals, as in the rotifers and in the social hymenoptera, the spermatozoon appears to have a determining influence. In the mammals the entrance of the spermatozoon may have only the same in-

fluence as that of the egg itself. It will be observed that there is a certain catholicity in these conclusions at which Cuénot arrives, and in the present uncertain state of our knowledge on many important points it is probably wiser not to take too narrow a point of view in regard to what factors determine the sex of the individual.

Strasburger* has recently arrived at a somewhat similar conclusion in regard to sex, basing his evidence mainly on certain observations and experiments in higher plants. He, too, concludes that the sex of the individual is determined in the egg, but he does not attempt to push the question further than this general statement.

Lenhossek† has also discussed in a more popular form the question of the determination of sex, and he likewise urges that the sex of the individual is determined in the egg. His discussion of the relative number of males and females born in the human race is particularly instructive, but it would carry us too far here to discuss the conclusions at which he arrives.

Born‡ has carried out a series of experiments with mice, and finds that the amount of food given to the parents produces no effect on the relative numbers of males and females born. He also finds that the age of the parents has no effect, nor has close interbreeding. He arrives at the conclusion that the sex of the higher animals and plants is determined in the egg.§

In striking contrast to the general conclusions of Cuénot, Strasburger, Lenhossék, and of Born there are two more recent theories in which an attempt has been made to describe in detail how the sex of the individual may be determined in the egg. Beard's paper,‖ published in 1902, may be said, in a sense, to take up the problem where it was left by Cuénot. He attempts to bring the problem of the differentiation of the sexes into connection with the recent work relating to the origin of the reproductive cells or gametes. Beard tries to show that there are not only two kinds of eggs, but also two kinds of spermatozoa that correspond to the two kinds of eggs. It is supposed by him, however, that the determination of sex rests entirely with the egg, and that the spermatozoa do not have any influence on sex-determination. It is assumed, moreover, that one of the two

* *Biologisches Centralblatt*, XX., 1900.

† 'Das Problem der geschlechtsbestimmenden Ursachen,' Jena, 1903.

‡ *Sitz. phys. med. Gesell. Würzburg*, 1902.

§ Born points out that while it has been shown experimentally that in hermaphroditic animals and plants, especially in the lower groups, it is possible to cause one or the other kind of sexual organs to develop or to be suppressed, that in the higher forms, at least in those in which the sexes are separated, it has been found that the sex can not be changed by external factors.

‖ *Zoologische Jahrbücher*, XVI., October, 1902.

kinds of spermatozoa has lost its power of fertilizing the egg and in most cases has become degenerate.

In respect to the occurrence of the two kinds of spermatozoa, Beard brings together rather a heterogeneous collection of facts. It has been known for some time that in a few cases two kinds of spermatozoa are found. The oldest and now the most thoroughly studied example is that of the snail, *Physa vivipera*. In this animal there are hair-like spermatozoa that resemble the ordinary forms of spermatozoa, and also worm-like forms which are as numerous as the other kind. A remarkable fact has recently been discovered by Meves in regard to these spermatozoa. An unusual and probably degenerate process occurs in the formation of the worm-like spermatozoon, so that instead of containing the reduced number (seven) of chromosomes it contains but a single one. In another form, *Pygæra*, this second form of spermatozoon contains no chromatin material whatsoever, *i. e.*, it is headless and presumably functionless as well.

In the long list of cases given by Beard in which two forms of spermatozoa have been described, there are several cases in which the two distinct forms appear to be always present and characteristic, as in the cases cited above; but he has also included some other cases in which giant spermatozoa occur, and some of these at least have been shown to be the result of a failure of the spermatocytes to divide. Until it can be shown that this failure to divide is usual and characteristic of one set of these spermatocyte cells the result may really have no bearing at all on Beard's contention.

Much more striking are the cases in which there is an accessory chromosome present in two of each of the four cells that develop from a single spermatogonial cell. The discoveries of McClung, Montgomery and Sutton in this connection indicate that there are two kinds of spermatozoa, and McClung has urged that this difference is connected with the determination of sex; but there is nothing more than the supposition that this may be so to go upon at present. In these cases, although the form of the spermatozoa is the same for the two kinds, there appears to be a difference in the amount of the chromatin material. It has not been shown that a difference of this kind would have any value in the determination of sex, and even if this were the case the results do not conform to the requirements of Beard's theory, as we shall see presently.

Beard calls attention to the fact that in nearly all the cases in which two kinds of spermatozoa have been described there is evidence of the degeneration of one of the two kinds. From this he draws the rather sweeping conclusion that throughout the animal kingdom one of the two forms of spermatozoa has become suppressed. He arrives at this conclusion in the face of an overwhelming body of evidence

to the contrary, for in the great majority of forms all the spermatozoa that are formed develop in the same way and are, so far as we can see, capable of fertilizing the eggs.*

Beard's conclusions in regard to the determination of sex may be summarized as follows:

1. The sex of the individual is determined in the egg before fertilization.

2. The determination of sex probably takes place at the time of the reduction in the number of chromosomes.

3. Each egg and its two polar bodies are potentially of the same sex, either male or female.

4. A corresponding differentiation of the primary germ-cells takes place in the male. An early separation of the spermatogonial cells into male and female occurs. After this each cell may continue to divide, but remains of the sex that it has acquired in the differentiating division. Finally each of these cells produces four spermatozoa. This division is comparable to the one in the egg-series when the polar bodies are given off, so that each group of four spermatozoa corresponds to a female egg and its three female polar bodies, or to a male egg and its three male polar bodies; but in the cases of the spermatozoa the individuals are supposed to be without sexual qualities. It is the egg alone that determines the sex.

5. One set of these fourfold groups of spermatozoa Beard supposes to have become functionless, in the sense that even if it develops the spermatozoa have lost the power to fertilize the eggs. The other spermatozoa are functional so far as fertilizing the egg is involved, but, as stated above, take no part in the determination of sex.

Beard also advances certain views in regard to parthenogenesis. The sex of the individual that develops from a non-fertilized; *i. e.*, from a parthenogenetic egg, is not in any sense a consequence of the non-fertilization of the egg. Whether the individual is a male or a female depends entirely upon whether a male or a female egg has been produced. Whenever we find long series of parthenogenetic females, as in the aphids, developing from and also producing parthenogenetic eggs, Beard supposes that only female eggs have been produced in the ovary, and that the male eggs, which have appeared in one at least of the first generations of the germ-cells 'must be either delayed in their ripening or suppressed.' Here we meet with a paradox that is so

* Meves has recently found in a male bee that two kinds of spermatids are formed by an unequal division of the spermatocyte. The smaller of the two, although it begins to undergo changes similar to those which in the larger one produce a spermatid, appears to be arrested in its development before the change is completed. *Mittheilungen Verein Schlesw.-Holst. Aerzte*, XI., Mai, 1903.

patent and touches such a fundamental point of Beard's theory that it is more than surprising that he has said nothing about it. If the female aphid develops from a female egg (the polar bodies of which are on Beard's theory also female), we can understand why in the next generation she must give rise to female eggs, but why should males ever be again produced? Since it has been established beyond question that these parthenogenetic females do produce both males and females at the end of the summer, the question is where have the male eggs come from?* Beard appears to take for granted that a female egg can give rise to cells that become male eggs. If so his theory can have very little if any value, since the entire conception on which it rests, namely, the separation of the male and the female eggs at one division, is rendered valueless, I think, by the assumption that after such a thing has once taken place a female cell may in the next generation give rise to male eggs. Furthermore Beard's assumption, that the separation of the male and the female eggs occurs at the time when the reduction in the number of the chromosomes takes place in the egg, is pure guess-work, and not very good guessing either, for certain recent work indicates that the reduction in the number of the chromosomes involves a process that can have no conceivable connection with the separation of the male from the female elements of the egg. On the whole it does not appear that Beard has offered a very convincing theory as to how the determination of the sex of the individual is accomplished.

Castle† also has recently advanced certain hypotheses in regard to the determination of sex. In certain superficial respects his view appears similar to that of Beard, but closer scrutiny shows that the two views are essentially different in many important points.

Castle assumes that there are two kinds of eggs, male and female, and two kinds of spermatozoa, male and female. He supposes that both kinds of spermatozoa are functional in the sense that each carries with it the possibility of determining the sex of the individual, and each spermatozoon is also capable of fertilizing an egg, but a male spermatozoon can fertilize only a female egg and a female spermatozoon a male egg. It is evident, therefore, that Castle's idea in regard to the spermatozoa is fundamentally different from that of Beard. Furthermore, Castle supposes that the separation of the male from the female qualities of each egg takes place at the time when the second polar body is extruded, and, in consequence, the egg and one of the polar bodies will be female and the other two polar bodies male, or if the egg remains female, one polar body will be female and the

* The same paradox appears wherever a female contains male eggs.

† *Bulletin Museum Compt. Zoology at Harvard College*, January, 1903.

other two male. Similarly for the spermatozoa; two of each four (formed from the first spermatocyte) are female, and two are male.

The evidence on which Castle rests his assumption that there are two kinds of spermatozoa, as well as two kinds of eggs, is contained in the following statement: "That sex is borne by the egg is shown clearly by the case of parthenogenetic animals, which without the intervention of a male produce young of both sexes. That the spermatozoon also bears sex is manifest in the case of animals like the honey bee, for the egg of the bee, if unfertilized, invariably develops into a male, but if fertilized into a female." The finality of the conclusions drawn from these facts is by no means above question.

Perhaps the most distinctive part of Castle's paper is his attempt to apply the much-discussed Mendel's law to problems of sex-determination; an idea that had suggested itself to Bateson and Saunders, but had been rejected, because the 'distribution of sex among first crosses shows great disparity from the normal proportions.' Castle does not admit however the force of this objection.

A specific example may be the simplest way of illustrating Mendel's law and its application to sex as maintained by Castle. If a white mouse is crossed with a wild gray mouse all the offspring of this first cross will be gray like the wild mouse. The gray color of the gray mouse is said to be *dominant* and the white color (inherited from the other parent) does not appear, but is supposed to be present in a sort of latent condition. It is said to be *recessive*. If now these primary hybrid mice are interbred some of their young will be white and the rest gray in the proportion of one to three. If these white mice, when they become grown, are interbred their offspring will always be white as well as all their subsequent descendants. Some of the gray mice will also breed true, but the rest that are gray hybrids will, if interbred, give rise to some white and some gray in the proportion again of one to three. This is only a partial statement of Mendel's law, but will suffice for our present purposes.

The explanation that Mendel offered to account for the proportionate number of individuals that inherit the dominant and the recessive characters is very simple and is probably correct. As applied to our illustration of the mice it would be as follows: When the egg of the white mouse is fertilized by the spermatozoon of the gray mouse the fertilized egg and all the cells into which it divides contain chromatin material in the nucleus half from the white and half from the gray parent. The dark element dominates whenever the two are together, hence the first generation of hybrids are all dark. The cells of this primary hybrid that have gone into the reproductive organs (in the female into the ovary and in the male into the testis) are supposed to be at first like all the other cells of the body, and contain both white

and dark elements.* But at some time in their later history, and presumably at the time when the egg sends off its polar bodies and at the time when the four spermatozoa are formed, a separation of the dark from the white elements occurs, so that two cells of the one kind and two of the other are formed. Thus the germ-cells are, as it were, purified, and consist of those that contain only white and of those that contain only dark elements. This is supposed to be the condition of the germ-cells in the ovary and in the testis of the primary hybrids.

Suppose now that these hybrids breed together, the white and the black spermatozoa will meet the white and the black eggs, and since it is a question of chance alone how they will come together, all possible combinations will be made. When a white germ-cell meets with a white one, a white individual results, and since it contains only white elements all its descendants will be white (if it is bred, of course, to white individuals). If a gray germ-cell meets a gray germ-cell, a gray individual will result, and all its purely bred descendants will be gray. If, however, a white and a gray germ-cell unite, the individual that develops will contain both elements in all its body-cells and, since the gray always dominates in such combinations, the individual will be gray, but will have the white as a recessive character that may crop out in subsequent generations. On the theory of chance combinations there will be twice as many of these gray-white individuals as of the white or of the pure gray. The series stands 2:1:1. Since in outward appearance all the gray-white mice are like the pure gray, we get three grays to every one white.

Let us now return to Castle's theory and see how he tries to make an application of Mendel's principle to sex. Just as there are two kinds of mice in our illustration, white and black, there are two kinds of sexual individuals, males and females. It is now assumed that the germ-cells, when they reach their final divisions, separate their male from their female elements, giving pure male and pure female eggs, and pure male and pure female spermatozoa. If, as in the mice, all chance combinations of the germ-cells are possible, there will result three kinds of individuals in the proportion of 2:1:1. The first of these, that are twice as common as either of the other two, would be *sex-hybrids*. If we assume, as in the mice, that one character always dominates in such a combination, the male let us say, there would be twice as many males of this hybrid kind as there are individuals of either of the other two pure kinds, and since there are as many pure males as there are pure females, there would be in all three times as many males born as females. Since we know that there is no such disproportion of one sex to the other, it appears absurd to attempt to

* More accurately, elements corresponding to the white and black colors.

apply Mendel's law to the problem of sex. Castle is therefore obliged to make a further assumption to avoid this difficulty. He assumes that a male spermatozoon can fertilize only female eggs, and a female spermatozoon only male eggs. There is no evidence known at present supporting this assumption, but it must be admitted that it can not be disproved, however improbable it may appear. On this view every fertilized egg is a sex-hybrid, and may give rise to a male or to a female according to which element dominates. Thus we return once more to our original question as to what determines the sex of the individual. We shall see presently that Castle fails to meet this fundamental question.

There is one result that Castle cites, which he claims indicates that his assumption that the eggs may show a selective power towards certain of the spermatozoa is not unwarranted. He found some years ago in the ascidian, *Ciona intestinalis,* that the eggs of one individual can not be fertilized by the sperm from the same individual, except very rarely. This case is cited as indicating that successful fertilization depends upon unlikeness between the gametes that unite. I have repeated this experiment on *Ciona* and have confirmed in large part this result, but, unfortunately for the point of view, I found in other ascidians that this relation does not hold. In *Molgula,* for example, the eggs are perfectly fertile with sperm from the same individual. Furthermore, by making the sperm of *Ciona* more active by adding ether to the water, I have been able to make them, under certain conditions, fertilize all the eggs of the same individual. In the light of these facts I do not think the conditions in *Ciona* can be given the interpretation that Castle has applied to them.

There is another side of Castle's hypothesis that must be briefly referred to, since he suggests a way of meeting a difficulty that is fatal to Beard's theory. I refer to parthenogenetic development and to the production at the end of a parthenogenetic series of male and female individuals. Castle supposes that in parthenogenetic reproduction the female character dominates over the male, when the two are present together, and that when a separation of the sex-characters takes place it does so at the time of the formation of the second polar body in the egg, and probably at the corresponding state of development in the spermatozoon. There is a fact in this connection, the bearing of which Weismann was the first to fully appreciate, namely, that the parthenogenetic eggs of daphnids and of some rotifers give off only one polar body, while eggs that are to be fertilized give off two polar bodies. Castle suggests that the second polar body is the female gamete, hence when it is given off the egg must become a pure male if it develops. If this polar body should be retained in the egg the conditions are exactly the same as when a female spermatozoon enters a

male egg. Hence, since the female element dominates in these animals when the two sexes meet, the individual must become a female. Since therefore such an egg carries the male element in a recessive form, this element may, if it becomes separated from its female associate, give rise to a male. In this way the theoretical difficulty referred to above is met.

Let us follow out a little further the applications of this view. It is probable in the honey-bee that all the eggs give off two polar bodies. Consequently unfertilized eggs must produce pure males. If they are fertilized by female spermatozoa they will give rise to females, and, on the hypothesis, only female spermatozoa can enter male eggs.

In rotifers and certain crustaceans only one polar body is given off, but since this is the first polar body it does not involve the question of sex. Consequently the parthenogenetic eggs in these forms are sex hybrids. If at any time the conditions change so that one or the other sex element dominates, males and females may arise. But why the female element should dominate in some eggs and the male in others is not explained, and thus we are in exactly the same predicament as we were before Castle's hypothesis was proposed.

One case of special difficulty should not pass unnoticed since Castle has made an interesting suggestion that appears to clear up a difficulty, provided the facts on which the conclusion rests are confirmed. The eggs of the honey-bee extrude two polar bodies, as we have said, and hence are purely male. It is assumed that these males must produce spermatozoa that are female. This is a necessary assumption, because the eggs of the bee having extruded their two polar bodies are purely male, but become female after they are fertilized. Therefore the spermatozoon must bring the female element into the egg. Castle tries to meet this difficulty of the formation of female spermatozoa in a purely male individual by reference to a recent observation of Petrunkewitsch, namely, that the reproductive organ of the male bee develops not from the egg itself, but from the second polar body which fusing with one of the first pair reenters the egg. This second polar body is, on Castle's theory, purely female, hence the spermatozoa must be female. The ingenuity of the explanation is admirable, and rescues the theory from a fatal objection, but of course even if Petrunkewitsch's results are accurate (and they are not above suspicion) it by no means follows that the spermatozoa that come from the second polar body are female, as Castle assumes. The facts in regard to the parthenogenesis, and in regard to the special case of the bee, may possibly be given a much simpler explanation than that which Castle applies to them. For instance, if in certain insects the addition of the chromatin material of a spermatozoon (or what amounts to the same thing the chromatin contained in a polar body) determines that the egg shall

become a female, we can explain the results without complicating the problem by the assumption of male and female spermatozoa, and male and female eggs. Castle's theory appears needlessly complex, and the whole attempt to apply the Mendelian principle to the question of sex does not appear to have been very successful. The weakest side of the theory has already been spoken of, namely, that it fails to account for the very problem that a theory of sex should explain, namely, the problem of what it is that determines whether an egg that contains both potentialities becomes a male or a female.

The reaction that has set in against the old view, that the sex of the embryo could be determined at a relatively late stage in development, is no doubt in the right direction. It has been shown in several cases by recent discoveries that the sex of the embryo is already determined in the fertilized egg, and in other cases it appears to be determined even before fertilization, but this need not mean that there are male and female eggs, and male and female spermatozoa. We have just examined two recent theories that rest on assumptions of this kind and have found, in my opinion, that they are both unsatisfactory. Let us see whether it may not be possible to bring under one point of view the old and the new discoveries in regard to the determination of sex, and construct a hypothesis that does not involve the idea that there is separation of the primoidia of sex in the germ-cells.

1. It has been shown in a few cases that two kinds of eggs are produced which become male and female individuals, in some cases with, in others without, fertilization. It may be erroneous to conclude from these facts that the eggs themselves are male and female in the sense that the elements (primoidia) that determine the sex of the embryo have become separated and confined to male or to female eggs. In a case like that of the silk-worm, where a graded series exists, the size of the egg appears to be the determining factor in respect to which sex develops, not that the female sex-elements are found only in the large eggs, and the male elements in the small eggs. It seems more reasonable to assume on the contrary that both elements are present in all kinds of eggs. In other cases other factors than that of size determine which sex develops.

In regard to the two forms of spermatozoa that have been found in a few species, there is no evidence that one sort contains only the primoidia of a male individual and the other kind those of the female. In those arthropods in which an accessory chromosome has been found we have no evidence to show that this chromosome is the male or the female element, and so long as we know nothing at all in respect to the conditions in the egg it is useless to speculate further on these cases.

2. There is experimental evidence pointing to the conclusion that factors, external to the egg itself, may determine in some species what kind of eggs will be produced, as in *Hydatina,* and in the aphids where a change in the food causes the appearance of males and females. In bees the addition of the chromatin of the spermatozoon appears as a rule to determine that the egg gives rise to a female.

In other cases it appears that the addition of the chromatin in one of the polar bodies may accomplish the same result. Here the relation may be purely a quantitative one. In other animals the addition of the spermatozoon to the egg is not, it appears, the factor that determines the sex.

3. It is known in bees and in butterflies that individuals sometimes appear that are male on one side of the body and female on the other side. The explanation of this peculiarity may be found in the unusual way in which the nucleus of the *fertilized egg* is divided. If, for instance, all or most of the chromatin brought in by the spermatozoon should be carried into one of the first formed cells along with half of the chromatin of the egg-nucleus, then all the cells that descend from this cell may develop female characters, and all those from the other, male characters. This need not mean that the spermatozoon has brought into the egg female characters that dominate in all the cells in which it is contained, but only that those cells that contain more of the chromatin differentiate their female characters, and all those cells that contain less chromatin differentiate their male characters only.

4. Having discovered that the sex is already determined in the unfertilized egg in some cases, and in others that it is connected with the process of fertilization, the question at once suggests itself whether the determining influence comes from the nucleus or from the cytoplasm. At present we have no conclusive evidence pointing in either direction. That the quantity of the nuclear material may be important seems probable in the case of the bee. That the size of the egg, which is due to a greater amount of cytoplasm, may be a factor in the result seems in other cases to be important, but so long as we do not know what relation the nucleus bears to the cytoplasm in these forms we can not decide as to the meaning of greater volume as a sex determinant. If, as seems highly probable, identical twins come from halves of the same egg, then since the pairs may be of either sex it seems to follow that the absolute size of the egg is not a factor. Whether in these cases the relative amount of chromatin in the nucleus enters into the problem remains to be shown.

It should be pointed out that while we must suppose that the influences in the embryo that control the *development* of one or of the other sex reside, or have resided, in the nucleus of the egg, this is a

different question from that as to whether the nucleus or the cytoplasm of the egg determines which of the two possibilities that are potentially present in the nucleus shall be awakened.

5. Our general conclusion is that while recent theories have done good service in directing attention to the early determination of sex in the egg, those of them which have attempted to connect this conclusion with the assumption of the separation of male from female primoidia in the germ-cells have failed to establish their point of view. The egg, as far as sex is concerned, appears to be in a sort of balanced state, and the conditions to which it is exposed, even when it is not fully formed, may determine which sex it will produce. It may be a futile attempt to try to discover any one influence that has a deciding influence for all kinds of eggs. Here, as elsewhere in organic nature, different stimuli may determine in different species which of the possibilities that exist shall become realized.

THE ACADEMY OF SCIENCE OF ST. LOUIS.

A Biography.

By Professor WILLIAM TRELEASE,
MISSOURI BOTANICAL GARDEN.

WHEN the Henry Shaw School of Botany was inaugurated as a department of Washington University in 1885 the venerable Dr. Eliot, then president of the board of directors and chancellor of the university, said that more than forty years earlier, five or six young men, of whom he was one, met together on Main Street, near Chestnut, in the office of Judge Mary P. Leduc, their object being to found an academy of science: "But," he said, "not one of our number knew enough of science to found a primary school, except Dr. George Engelmann, who was an enthusiastic student, especially in botanical research, and who inspired us all with something of his zeal. We organized a society and proceeded to purchase five or six acres of ground, far out of the city, I think near Eighth Street and Chouteau Avenue. There Dr. Engelmann began a botanical garden and arboretum on a small scale. It was kept up, after a fashion, for some years, but the society faded out and the land was sold, and apparently there was an end of the academy; but under the law of the survival of the fittest, Dr. Engelmann 'survived' and became an Academy of Science in himself."

Engelmann, however, was not the kind of man to work indefinitely without closer association with the few other St. Louis men interested in science than was afforded by chance, and on March 10, 1856, after several preliminary meetings, the existing Academy of Science of St. Louis was organized. It is recorded that the men in attendance at the meeting for organization were, in addition to Dr. Engelmann, who acted as chairman, Charles P. Chouteau, James B. Eads, Nathaniel Holmes, Moses L. Linton, William M. McPheeters, Moses M. Pallen, Simon Pollak, Charles A. Pope, Hiram A. Prout, Benjamin F. Shumard, Charles W. Stevens, William H. Tingley, John H. Watters and Adolphus Wislizenus.

A previously appointed committee, consisting of Tingley, Prout, Shumard and Holmes, reported a constitution and by-laws, which were adopted. The original constitution, which was amended somewhat in the course of the first year, consists of six articles, referring respectively to style, objects, members, officers, meetings and amendments. The second article is so important that it is here quoted in full:

Section 1. It shall have for its object the promotion of science: it shall embrace zoology, botany, geology, mineralogy, paleontology, ethnology (especially that of the aboriginal tribes of North America), chemistry, physics, mathematics, meteorology and comparative anatomy and physiology.

Section 2. It shall furthermore be the object of this academy to collect and treasure specimens illustrative of the various departments of science above enumerated; to procure a library of works relating to the same, with the instruments necessary to facilitate their study, and to procure original papers on them.

Section 3. It shall also be the object of this academy to establish correspondence with scientific men, both in America and other parts of the world.

Membership was divided into associate and corresponding classes, the former, constituting the main body of the academy and exclusively entrusted with the conduct of its affairs, to include 'men desirous of cultivating one or more branches of science above enumerated,' while corresponding membership, as is usual in such cases, was intended for eminent men of science and other persons not residing in or near the city, but disposed to further the objects of the academy by original researches, contributions of specimens or otherwise. The customary provisions were made for election, lapsing of membership and expulsion for cause, no person expelled being under any circumstances admissible to reelection. The provisions referring to officers, meetings and constitutional amendments are such as are usually adopted.

The original by-laws likewise contained six articles, referring respectively to committees, library, museum, communications, meetings, and authority. Apparently provision for amendments was not thought of, or was considered unnecessary.

The scope of live interest of the original members may be inferred from the section providing for standing committees, which were to represent ethnology, comparative anatomy, mammalogy, ornithology, herpetology and ichthyology, malacology and chemical geology, entomology, botany, paleontology and geology, mineralogy, chemistry, physics, embryology and monstrosities—in addition to library and publication committees. These standing appointive committees, in conjunction with a board of curators provided for in the constitution as elective officers, were charged with the care of their respective departments and expected to make exchanges of duplicates, to arrange, label, catalogue and keep in order all donations and deposits, and to report in writing at a specified meeting each year. The somewhat quaint by-laws referring to the library and museum contain such provisions as were thought desirable to ensure the greatest good to the greatest number in their use. The article on communications provides for the reference of those designed for publication to special committees, for the preservation in the archives of all, whether published or not, and for discussion of original papers on the subjects before enumerated. Fortnightly meetings were arranged for, with an adequate order of business, and current rules of order under the heading 'authority.'

Steps appear to have been taken promptly for securing a charter or act of incorporation from the legislature, and such an act was passed the next winter, approved on the 17th of January, 1857, and presented and adopted at the academy meeting of February 9 following.

The charter provides that under the name of The Academy of Science of St. Louis the incorporators and their associates and successors shall have perpetual succession, may sue and be sued, implead and be impleaded in the courts, may acquire and dispose of real, personal or mixed property for the advancement of science and the establishment in St. Louis of a museum and library for the study of its various branches; that they may have a common seal and break or alter the same at pleasure, and may make and alter such constitution, regulations and by-laws, not contrary to the laws of the land, as may be requisite for their government. Exemption from taxation is provided for all property owned or held by the academy so long as it is held and used in good faith for the designated objects, except that leasehold interests which may be granted to other persons are made taxable. It is distinctly stated that members acquire no individual ownership in the property and effects of the academy, their interest in the same being declared to be usufructuary merely, and not to be transferred, assigned, hypothecated or otherwise disposed of except by corporate act of the academy: and whenever the corporation shall have failed to answer the purposes for which it was created, or shall suffer its charter to be forfeited by the law of the land, its cabinet, collections and library are to revert to and become vested in the City of St. Louis, to be deposited with some public institution in the city, for general use and inspection, under such regulations as the city may prescribe.

One or two of the gentlemen present at the first meeting appear to have taken little active part in the affairs of the academy, but most of them were evidently much in earnest, and these, as well as some of those whom they proceeded to elect to associate membership, attended the fortnightly meetings with regularity. Arranged in the order of the frequency with which their names are recorded in the roster of members at the meetings of 1856, these more active charter members stand thus: Pope, Holmes, Pallen, Pollak, Stevens, McPheeters, Prout, Shumard, Engelmann, Wislizenus, Eads, Tingley and Chouteau. It is not difficult to analyze the constitutional provisions and the early activity of the academy in connection with the interests and attainments of these original members.

Charles A. Pope was one of the most brilliant surgeons of the West, and dean of the St. Louis Medical College. He is said to have possessed personally a very valuable museum collection, representative of morphology and comparative anatomy. The records for 1856 show that at the meetings of that year he presented to the academy or deposited with it 'A specimen of eyeless fish (*Amblyopsis astacus*) from Mammoth Cave, Ky., petroleum from Arkansas, and an insect, also specimens of rock salt and other minerals from Hallam near

Salzburg'; 'Specimens of *Productus* from the Carboniferous limestone of St. Louis Co.'; 'A weasel'; 'Specimen of a grizzly bear'; 'An interesting suite of Cretaceous and Tertiary fossils, specimens in zoology, and Indian curiosities'; 'Two specimens of horned frogs from South-West Missouri'; 'Indian curiosities . . . also a fine specimen of fossil turtle (*Testudo Oweni*) from Nebraska'; 'Specimen of *Heliophyllum Halli*, a *Chaetetes*, and a *Spirifer*'; 'A specimen of tarantula, found . . . seventy miles below St. Louis' and 'A tarantula and a centipede from Texas, also shells from North Alabama.' He was better able than any other member to afford material assistance to the academy in its early days, through his connection with the medical school, and promptly offered to the new body a meeting room in the building of the O'Fallon Dispensary, connected with the Medical School, and the use of the collections in his hands. He was made chairman of the committee on comparative anatomy.

Nathaniel Holmes* was a lawyer of wide interests and versatile talents who later removed to Cambridge as Royal Professor of Law in Harvard University. He was promptly elected corresponding secretary, and held that office for many years, making a practice of intelligently reading the more important of the academy's exchanges—for the reception of his analyses of which a special order of business was established. It was mainly through his efforts that the academy was placed on the mailing lists of foreign bodies at a time when it had nothing to offer in exchange, and in this way he contributed more, perhaps, than any other member to perpetuating it when its life flagged.

Moses M. Pallen† was one of the active physicians of the city, and a professor in the St. Louis Medical College. He was made chairman of the committee on herpetology and ichthyology.

Simon Pollak, who died in St. Louis a few weeks ago, at a very advanced age, was an active physician.

Charles W. Stevens was a physician, an excellent anatomist and a professor in the St. Louis Medical College. He was made chairman of the committee on mammalogy, and, before the end of the year, recording secretary.

William M. McPheeters, still living in St. Louis, and the sole survivor of the founders of the academy, was a physician of broad interests and a professor in the St. Louis Medical College. He was made chairman of the committee on entomology.

Hiram A. Prout‡ was a physician. He was made chairman of the curiously devised committee on chemical geology and malacology. He appears to have taken an active part in most of the meetings that he attended.

Benjamin F. Shumard§ was a physician and also a professional geologist well known as an authority on paleontology. He was at this time occupied with the geological survey of the State, and soon after the organization of the academy was made state geologist of Texas. He was naturally chosen as chairman of the committee on paleontology and geology.

George Engelmann‖ was likewise a practising physician, who found much time for scientific research. He was a recognized authority on botany, and, among other interests, cultivated meteorology, and he was justly regarded as the leading scientist of the west. He was the first president of the academy, was frequently reelected to that office, and stimulated many of its activities.

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* Trans. Acad. Sci. of St. Louis. **11**: xxvii.
† Trans. Acad. Sci. of St. Louis. **3**: ccxxii.
‡ Trans. Acad. Sci. of St. Louis. **2**: 178.
§ Trans. Acad. Sci. of St. Louis. **3**: xvii.
‖ Trans. Acad. Sci. of St. Louis. **4**: xc, and Supplement.

Adolphus Wislizenus * was a physician, intensely interested in meteorology, electrical phenomena, etc. He was made chairman of the committee on ethnology.

James B. Eads † was a civil engineer, broadly trained and interested in the scientific aspects of his profession. His name will long be remembered in connection with the first St. Louis bridge and the jetties at the mouth of the Mississippi River—his creations. He was made chairman of the committee on physics.

William H. Tingley was a physician, and actively served the academy as secretary until his removal from the city, which occurred before the end of the first year.

Charles P. Chouteau ‡ was the St. Louis representative of Mr. Astor's great fur house, an extensive traveler in the Northwest, and in close touch with the work being done by Hayden in the then new and still wonderful 'Bad-Lands.' At the meeting of April 21, 1856, he offered to deposit with the academy (and to present his personal interest of about one fourth in them) the collections already made by Hayden, as soon as a place was fitted to receive them. This gift was but one of many, and he soon put the academy in the way of utilizing the great resources at his command in the many trading posts of the upper Missouri and its tributaries.

It is not by chance or without significance that 'M.D.' is affixed to the names of all the founders of the academy except Chouteau, Eads and Holmes, or that before the end of the year 1856, when the original associate membership of 15 had been increased to 104, no less than 35 of the first additions to the roll were also physicians, for it was in the courses preparatory to and immediately concerned with medicine that the chief opportunity for scientific study lay half a century ago.

At the first meeting of the academy Dr. Engelmann called attention clearly to the fact that its firm establishment demanded the provision of an endowment fund; and it was also noted that the valuable collections of fossil remains and other natural objects then in the city ought to be secured for permanent preservation. Little success appears to have rewarded the efforts to raise money; but by making almost every one of the original members the head of a committee charged with some branch of museum activity, the acquisition of specimens was greatly stimulated. The record of Dr. Pope's gifts during the first year might be paralleled, if not equaled, by entries concerning the gifts of other members.

After one or two abortive efforts to affiliate with the new academy a private museum which then existed in St. Louis, Dr. Pope's offer of a home with the medical school was accepted, and the property of the earlier Western Academy of Science, referred to above, was given to swell the rapidly growing collections. The museum was evidently the first love and mainspring of the new academy. Though money was not available for extensive purchases, and the records show that even a

* Trans. Acad. Sci. of St. Louis. **5**: xxxvii, 464.

† Trans. Acad. Sci. of St. Louis. **5**: xiii.

‡ Trans. Acad. Sci. of St. Louis. **11**: xxi.

taxidermist was kept for a time to care for the material which was presented only through the advance of his salary by members month by month, one of the first principles in museum administration was practically recognized before the end of April in the authorization of a collecting trip in search of some important fossils that were then being talked of; and Mr. Chouteau several times allowed a representative of the academy to accompany his parties into the northwest.

In gathering the nucleus of a library, which went hand in hand with the formation of a museum, letters were sent to learned bodies which published scientific matter. In the course of this correspondence it was learned that the valuable Smithsonian 'Contributions to Knowledge' could be sent only to societies able to offer an equivalent in published matter, which clearly brought before the new academy the exchange value of such publications; and even before this point was so emphasized, a committee had been appointed to consider the question of undertaking some publication on the part of the new academy. At the meeting of August 25, 1856, preliminary steps were taken toward launching this venture, though the members present seem to have been in doubt not only regarding its financial possibility, but as to the productive activity of the small working membership. At the next meeting, however, the practicability of undertaking the publication of papers was shown, and doubt as to the immediate power of the academy to furnish creditable matter for publication was removed by Dr. Shumard's offer of a paper by himself and Dr. John Evans, on new species of fossil shells from the Cretaceous formation of Nebraska. Other papers were soon handed in, and the initial number of the new 'Transactions' was issued early in 1857. It contained, in addition to the charter, constitution and by-laws, journal of proceedings, etc., this paper by Evans and Shumard, a description of a new *Productus* by Prout, an account of glycerine by Schiel, a paper on phyllotaxis by Hilgard, an account of certain *Mastodon* remains by Koch, a study of the inscriptions on a brick from Nineveh by Seyffarth, an account of Indian stone graves in Illinois by Wislizenus, descriptions of new crinoids by Shumard, an account of the geological formations underlying St. Louis, as shown by the Belcher artesian well borings, by Litton* and the first of a long and important series of local meteorological records by Engelmann and Wislizenus.

There does not appear to have been much change in the academy during the first few years of its life. Before the end of the first year, Engelmann, to whom the elaboration of the Cactaceae collected on the United States and Mexican boundary survey had been entrusted, so

* Dr. Abram Litton (Trans. Acad. Sci. of St. Louis. **12**: xxiv) was elected at one of the first meetings after the organization of the academy and was the first thoroughly trained chemist west of the Mississippi. He was made chairman of the committee on chemistry.

arranged his medical practise as to permit his absence for about two years, spent with Gray and in Europe—and a new president was of necessity elected; but the office was well filled by Shumard, who during this period was the leading investigator among the members. Meetings were held regularly. The museum continued to grow, and accessions to it to be reported. Occasional and for the most part good papers were contributed to the transactions, thus furnishing means for the increase of the library through exchanges, and Holmes presented abstracts of the most important or interesting of the accessions. But the raising of money for other than current purposes seems to have been given up, and with the hard and trying times of the civil war the border city of St. Louis could have been expected to concern itself but little with science. And yet in the gloomy year of 1863 twenty-two meetings were held, with an average attendance—ignoring two meetings for which the number is not recorded—of eight members. At these meetings letters were read from corresponding members, of whom a goodly number of the distinguished men of the day had by this time been elected, and from institutions with which relations had been established; and exchange publications were laid on the table and discussed. For some meetings nothing more is recorded, but a knowledge of the men who were constant in their attendance makes it certain that much unrecorded comment on the scientific work and spirit of the times should be read between the lines of the journal. On other occasions scientific communications or informal accounts of work in hand were presented. In his report on that year's activity of the academy, Engelmann justly takes pride in the collections and library already acquired, the inauguration of the second volume of transactions, and the fact that two hundred exchanging institutions of science, in all civilized countries, were bidding God-speed to the struggling St. Louis body. Only sixty active members, however, were reported at this time, and the publication of transactions had placed a *per capita* debt of about ten dollars on each of these. The testimony of surviving members of this period is not needed to show that the life of the academy then hung in the balance; but the men who were interested in its existence were not the sort of men who let their efforts come to naught, and it would have been more surprising if it had died than that it lived. The war came to an end, the country, freed from the great strain it had been subjected to, prospered, new members came to replace those who had died or removed, and the academy continued to exist.

In retrospect, we are often tempted to wonder what would have come about if some particular thing had or had not happened; and the temptation is present here. The thing that did happen at this point in the history of the academy was a disastrous fire which destroyed that part of the medical building in which the academy met,

early in 1869, and wiped out the collections of Dr. Pope, and with them nearly all of the academy's museum. The library, then numbering not far from 3,000 volumes, fortunately was saved, through the activity of a few members, and most of the reserve copies of the academy's transactions, which had been covered by a falling floor, were included in this salvage.

Even before the fire, the academy had outgrown the accommodations that had been given it by Dr. Pope, as is shown by the appointment, some time before, of a committee to try to secure new and more ample quarters. Without the check of this fire, cramped surroundings might perhaps have caused stagnation in the material growth of the academy: but the loss of the museum effected lasting and at the time all but complete paralysis of this side of its activity. Still, out of the fire came sympathy, encouragement and some help. New quarters were offered in the public school board's building, and the public school library shelved its books; but the academy was a tenant-at-will, restricted in its powers, without funds for amplifying its collections or properly caring for them, and the need of putting it on a safer basis was so unmistakable that in 1872 a serious effort was again made to secure endowment funds. As a result of this effort, which was shared by the Missouri Historical Society, the academy was made the recipient, through the generosity of Mr. James H. Lucas, of a building site on which a home for the two societies was to be erected. Only $50,000 was considered necessary for the construction and maintenance of an adequate building; but even this sum was not forthcoming, so that ultimately the academy sold its share in the building site and put the money out at interest, and still has it, with some additions, safely invested.

For another dozen years the academy continued to meet in the quarters to which it moved after the fire. Another effort to secure a home was made and failed. Then for a like period it enjoyed the hospitality of Washington University. When the rooms that it occupied there were needed for university purposes, more than a decade since, it became a tenant of the Missouri Historical Society, which, unlike the academy, had at last secured a home of its own. There was thus secured a meeting room and limited shelving for the library, but such museum material as the academy possessed has been stored, for the most part, in basements and out-of-the-way places, where it has been of little use to members or to the public.

The interest felt by the early members in scientific effort at the great centers of such activity, as has been said, led to early association with prominent workers abroad, from whom publications and communications were received. The prompt establishment of such relations, fortified by the commencement of the academy's own activity as a publishing body, quickly resulted in the formation of a valuable

scientific library, especially rich, naturally, in the publications of organizations having objects similar to its own. Most of these exchanges have been received without interruption, and prove invaluable to investigators who desire to go into the earlier literature of their subjects. At the end of 1902, 569 exchanging institutions were reported by the librarian, and the library contained 14,491 books and 11,017 pamphlets. Unfortunately, lack of room has caused these to be rather difficult of access for some years past, and the index, started many years ago by Dr. Baumgarten, has fallen into arrears. The latter fault, however, is in process of correction, and it is believed that the library will be more usable and more used in the future than has been the case heretofore.

In the homeless state in which the academy has passed the last third of a century, little inducement has been found for the accumulation of museum material that could not be displayed and could scarcely be housed. Some things, however, there are, which will form a nucleus for the museum of the future, for while the activity of the academy has been concentrated of late on holding meetings and publishing its transactions, the original inclusion of a museum among its prominent objects has been neither forgotten nor discarded. Among the present collections are a dozen or so of good fossiliferous slabs from various formations, some of them of unique value; a few remnants of the Hayden collection saved from the fire, containing among other things the type of *Tetanotherium Prouti;* a good specimen of *Bos cavifrons;* some ten thousand paleontological specimens brought together by Yandell, containing his own types and those of many of the species described by Shumard, whose own poorly preserved collection, of about the same size, is owned by Washington University; several hundred specimens of pottery from the mounds of southern Missouri, on which is based a quarto publication by Evers, issued by the academy some years since; two or three dozen human crania from the same district, the measurements of which have proved so divergent from those of skulls of comparable periods that those to whom their study was entrusted have never ventured on a description of them; several dozen meteorite specimens, of which the most important is one originally weighing about 35 pounds, which is described and figured in the first volume of the academy's transactions; and a collection of over 600 butterflies, beautifully mounted on Denton tablets, was presented to the academy a few years ago by subscription, through the efforts of Mrs. W. L. Bouton.

It may seem to have been by chance, but I think it appears from what has already been said that it was not, that the early existence of the academy was closely associated with the St. Louis Medical College, and that leading members of the faculty of that institution have always been among its active members. Too much credit can not be given to

these men when the history of St. Louis comes to be written. Busy physicians, they gave their services free of cost to the school they established, letting its earnings go to form a permanent medical fund, the ultimate wise use of which they did not question, though they provided against its alienation. Step by step they raised the grade of their school until it compared favorably with the best of the Eastern medical schools, though in doing so they sacrificed financial success; and at length, that it might enjoy the broadest affiliation, they merged it with Washington University, in which St. Louis always has had confidence and in the development of which it feels justifiable pride to-day. And yet, though professional men, they did not go into the academy for 'shop talk.' The meetings have never been closed to discussions of interest to the medical profession, but of their own volition these men presented only subjects of scientific interest. Even while they were the principal active members, geology, meteorology, botany and ethnology were the chief subjects of discussion, and the papers presented for publication show a keen discrimination between the art of medicine and the sciences, on some of which it rests.

Up to the time of its removal from Washington University, the academy met in a rather informal manner. My own connection with it dates from the autumn of 1885, when I came to the city to live. The notices that I received were more commonly to the effect that the next meeting would be held at a certain time and place than with any indication of what would be done at the meeting. On a long table were to be found the recent additions to the library. At the head of the table sat the president and recording secretary. Around it were half a dozen or a dozen members who looked over the papers between attending to the items provided for on the order of business. When 'written communications' were called for, a paper for publication might be handed in, sometimes accompanied by an oral abstract, sometimes not. The order 'oral communications' was pretty sure to lead some member to produce a specimen, piece of apparatus, or recent publication, on which he spoke, usually in a way to interest everybody present. Not infrequently nearly the entire body, like a German scientific gathering, gravitated after adjournment to a summer garden or winter 'Lokal,' where the discussion was apt to be continued over a glass of beer until the younger men felt that it was time for them to set their faces homeward.

Ladies were occasionally interested in the rumor or announcement that some particular paper was to be presented, but they appeared awed by the informality of the seating about the board, and could rarely be made to feel welcome after a tortuous wandering through the long halls and museum at the top of the University had led them to it. In the meantime the membership had greatly changed. Shumard, Prout, Pope, Swallow, Eads, Holmes, Wislizenus and Engelmann had

dropped from the active workers. Even the places of their successors had been taken by a younger generation, and the number of non-professional members had been very greatly increased.

These are some of the causes which led to a serious consideration, in 1893, of means for further widening the academy's influence and usefulness, a first step toward which was the appointment of a committee to report on the desirability of a revision of the constitution. On the report of this committee, the constitution was considerably changed, not in essentials, but radically by the adoption of a letter ballot for elections, amendments and the like, in place of the vote formerly taken at a regular meeting after due notice of the business to be done; and by provision for the election of a non-office-holding committee each winter to nominate officers for the ensuing year, with the privilege of additional nominations from the floor when the committee reported.

Direct effects of these provisions were to check a perfunctory renomination of officers to which informal nomination on the spur of the moment may lead along the line of least resistance and to place the franchise in the hands of the entire membership instead of leaving it through non-attendance to the few members who might be at the meeting when a vote was taken. Current matters of administrative business were also taken out of the hands of the membership and directly vested in a council, consisting of the principal officers. No doubt the general result of the innovations was good.

Some notable changes in the life of the academy showed themselves very soon after the revision of the constitution and the removal of the meeting-place from Washington University to the building of the Missouri Historical Society. For instance, the provision of a nominating committee having time for reflection and compelled to hold a meeting for the preparation of a list of nominees has led to a more frequent nomination of men of affairs for the offices of president and vice-presidents, as a means of identifying the non-professional majority of the members with the life of the academy, in place of the customary election to those offices of the most distinguished scientific men on the roll, or of those whose attendance was most constant; and the removal of business details from the meetings has cut out many spicy discussions on the financial standing and intentions of members in arrears and other non-technical matters, leaving the sessions free for the strictly scientific purposes of the academy.

Perhaps the most noticeable change of this period has been in the character of the program. In its new quarters, the academy met in a formal lecture room, with a platform for the presiding officers and regularly placed seats for the audience, the exchanges being displayed in a separate room, for inspection before the meeting. Attendance was made easier and the presence of ladies was more frequently

noted; but almost in the turn of a hand, the charming impromptu character of the meetings gave place to formality. Current publications were not brought in by those who, if they had had them in hand, would have commented on them. Specimens not announced were not brought to be shown if opportunity offered. Apparatus, chiefly from the laboratories of the university staff, which had been easily exhibited when the meetings were held under the university roof, was rarely taken down, transported and rearranged where facilities were few, with the certainty that the reverse process must be gone through in the busy hours of the following day. So it quickly came about that if nothing was announced for a given meeting little or nothing was offered, and the council was thus compelled to provide a stated program for each meeting, which contributed to cut out the last remnant of spontaneity in offering the many small things which go to make up the daily life of the teacher, investigator or reader, and which, fresh from his own life, are of greatest interest to his associates. To counteract this regrettable loss, the council, for the greater part of the past decade, has striven to make the program of evident interest to the non-professional members by providing, at least for alternate meetings, lectures divested of technicalities on matters of current scientific progress. Do what they may, however, though they have succeeded in winning the approbation of the non-scientific contingent, they have not much more than doubled the average attendance, while the membership has correspondingly grown; and they have not secured the attendance of any considerable number of members or other persons not themselves closely identified with pure or applied science.

It has been evident for several years past that the accommodations at the historical society's building were inadequate to the needs of the academy, and access to the building had become less convenient because of great changes in the location of the residence section of the city. This led to another effort being made, a year or two ago, to secure the much needed building; and again little reason was found for hope. But during the present year, as a gift from Mrs. William McMillan and her son Mr. William Northrop McMillan, the academy has been put in possession of a building, conveniently located with reference to intersecting car lines traversing the now widely separated residence districts. It was originally built for a private school, and has therefore been found directly adapted to many uses of the academy; such changes as were needed and practicable have been made, and the building has been renovated and equipped with modern heating and lighting appliances.

With the opening of the fall, therefore, the academy, for the first time in its existence, meets in its own home, and this, fortunately, not only without any encumbrance of debt, but with a small invested fund

which its friends now hope to see rapidly swelled to an adequate endowment. It may safely be said, therefore, that the hitherto always present question whether or not the academy might some day find itself without a meeting-place or the means of securing one is finally answered in a very satisfactory manner; and official and personal expressions without number testify to the warm gratitude with which those who have so long struggled with little more than hope to support them have witnessed the laying of this solid foundation of security for the future. That their struggles are at an end, however, they can not flatter themselves. Ample as the new building is for the present life of the academy, it is but temporarily suited to the housing of valuable collections, since it is not fire-proof; and one of the first things for future activity to accomplish is the provision of a suitable fire-proofed library and museum at the rear of the present building—for which ample space exists. Very unfortunately, too, while the academy is nominally able for the first time in many years to arrange its library and more important collections for convenient public use, it is actually confronted by the necessity, which has heretofore been felt by its late host, the historical society, of utilizing no inconsiderable part of its new home for purposes of revenue, by housing other homeless bodies, so that, as heretofore, its publication resources may be maintained. It is probable that many a vision of a reading room in constant use by investigators and science teachers, and of synoptical rooms thronged with nature and science classes from all grades of the schools of the city, will still be dreamed for some years by the council before giving place to the realities. That the academy will ultimately be enabled to perform this part of its functions, however, should now be certain; and the arousing of public interest in such matters which the world's fair and its congresses and the national scientific meetings of this winter are sure to lead to, makes it reasonable to hope that the time when this may be accomplished lies not very far in the future.

In its inner life, as well as in its outer semblance, the academy is not unlikely soon to experience marked changes. Its activity as a center of publication will doubtless remain unchanged. With the growth of the city, of the medical schools and of Washington University, with which many of its most active members have always been connected, scientific results of merit are certain to be offered for publication in increasing number; and there is little reason to question that in the future, as in the past, no paper of real value will lie long in manuscript awaiting the funds essential to its publication. As is necessarily true of most learned bodies, the world over, the academy's transactions are of an undesirable heterogeneity in their subject-matter, but their publication in brochures, each devoted to a single paper, ensures the availability of each paper when the entire volume is not desired; and if a national agreement were ever to be reached by which

the functions of publication were delegated by the principal scientific bodies to a central bureau, in such manner as to secure a subject division of volumes, it is not probable that the Academy of Science of St. Louis would be found to oppose such a step, though its isolation may prevent it from taking the initiative.

Perhaps the most probable immediate change in the inner working of the academy lies in the direction of its meetings. It is hardly to be expected or even hoped that these as a whole will ever revert to the character of those held when Holmes presented critical and spicy analyses of the contents of such publications as came to hand, or Engelmann or Riley chatted from the master's seat on investigations being carried on. Publications to-day are too complex for most amateurs of science to care to follow them in detail, and the minutiae of current research promise but small audiences for their advance presentation.

In these changed conditions lies the mainspring of probable changes in the organization and meetings of the academy. No doubt, as heretofore, the results of research offered for publication will be presented at the general meetings, the manuscript, with data for discussion by experts, if these are present, lying on the table, and the processes and conclusions being briefly and clearly presented in abstract from the floor. No doubt, too, at such intervals as may prove best, specialists will continue to present in untechnical language, comprehensible to laymen and teachers, analyses of progress achieved in the scientific world. But it is more than probable that these general meetings will be supplemented by others held by small sections of restricted aims, within each of which will be found the enthusiasm for current literature and the warm interest in special detail that characterized the earlier meetings of the academy as a whole.

Under the constitution, such sectional organization is provided for. If I do not mistake the drift of the times, the growing number of engineers and chemists, whose professions rest upon and demand a continued touch with the current progress of science; of physicians and pharmacists, whose professional life is full of opportunities for the observation and record of scientific detail and generalization and of teachers with university training, but so fully occupied with the daily routine that they can not for the moment do research work although they can not afford, if they would, to lose touch with what others are doing in biology, chemistry and physics—are going to find in the organization of sections in the academy the most logical and economical way of meeting their own needs, while through community of interest they will reach a unity of purpose which will inevitably react on the entire community, to the common good.

THE TETRAHEDRAL KITES OF DR. ALEXANDER GRAHAM BELL.*

By GILBERT H. GROSVENOR,
EDITOR OF THE NATIONAL GEOGRAPHIC MAGAZINE.

I HAVE been asked by the editor of THE POPULAR SCIENCE MONTHLY to write an article for that journal describing the tetrahedral kites of Dr. Alexander Graham Bell. I am glad to comply with his request, especially as I have had the good fortune for several summers past to watch the marvelous kites which Dr. Bell has been building in his laboratory at beautiful Baddeck, Nova Scotia. In this brief article there is not space to describe all the experiments that have been made, and I shall endeavor to explain, therefore, only the more important principles that I have seen evolved.

Dr. Bell began building kites in 1899. He was led to experiment with them because of his interest in the flying machine problem and his belief that a successful kite will also make a successful flying machine. A kite that will support a man and an engine in a ten-mile breeze will probably also support the man and engine when driven by a motor at the rate of ten miles an hour. This proposition has not been actually proved, but there can be little doubt that it makes no difference whether the kite is supported by the motion of the air against it or by its own motion against the air.

In a calm a kite rises when it is pulled by a man or horse, because of its motion through the air; there is no reason to believe that it would not also rise when urged through the air by propellers. A kite then can be changed to a flying machine by hanging a motor and propellers to it and dropping the string which attaches the kite to the ground.

The first kites that Dr. Bell built for his experiments were of the Hargrave box type, which had been the standard kite since its invention by Mr. Laurence Hargrave, of Australia, in 1892. Small Hargrave box kites flew very well, but their flying ability became poorer as their size was increased; a gigantic Hargrave with two cells as big as a small room would not sustain itself in the air, and experiments showed that only a hurricane could make it fly. To obtain much lifting power with box kites it was necessary to send up a number of

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them hitched on one line. But Dr. Bell's object was great lifting power in one kite and not in a team of kites. He realized that he was thwarted at the very outset by an old law, which was recently formulated by Dr. Simon Newcomb and which has made many believe that the flying machine is impossible without the discovery of a new metal or a new force. This law is that the weight of kites or machines built on exactly the same model increases as the cube, when all the dimensions are increased alike, while the supporting or wing surface increases as the square.

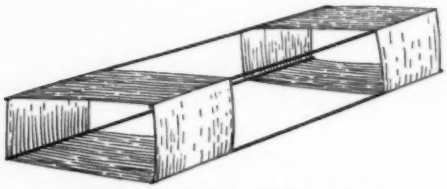


DIAGRAM 1. HARGRAVE BOX KITE.

A Hargrave box kite two meters on a side weighs eight times as much as one that is one meter on a side, but it has only four times as much sustaining or wing surface; the weight is tripled, while the wing surface is doubled; hence as the size of a box kite is increased a point soon comes when the weight is so great that the wing or supporting surface will not lift the weight.

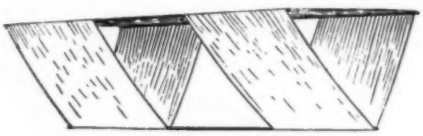


DIAGRAM 2. TRIANGULAR CELLS.

Dr. Bell then set to work to see if he could not outwit this law by devising a new form of kite which he could enlarge indefinitely without the weight increasing faster than the wing surface. He saw that if he could get a large kite by combining many small kites instead of by increasing the dimensions of his model the weight would not increase faster than the wing surface. He decided, therefore, to combine many small cells into one large kite instead of using two large cells each as big as a barn door. The Hargrave box cell however did not lend itself to combination. Two box cells fly well, but when a number of them are tied together they do not act with the same harmony. A box cell is structurally weak in all directions and requires a great deal of bracing to keep it from being twisted in a strong breeze; this bracing adds to the weight and makes head resistance to the wind; the more cells combined together, the more bracing required proportionally. Furthermore, the cells must be grouped in two sets at a distance from each other, and as the sets tend to pull apart, the framework connecting the two sets has to be very strong and heavy. As a result the experiments showed that neither

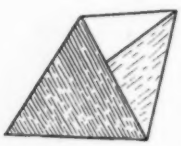


DIAGRAM 3. REGULAR TETRAHEDRAL WINGED CELL.

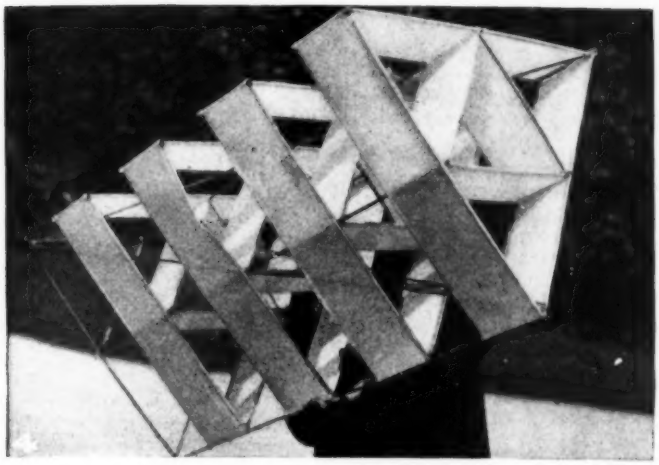


FIG. 1. KITE BUILT OF TWELVE TRIANGULAR CELLS. It is formed of two triangular kites, one inside the other.

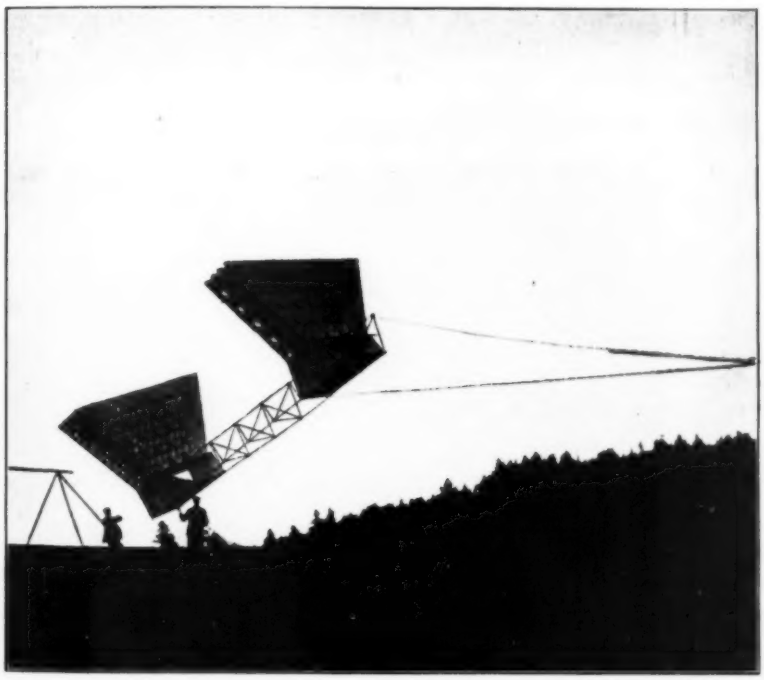


FIG. 2. GIANT KITE BUILT OF TRIANGULAR CELLS. The superstructure consists of seventy kites, like the one in Fig. 1, tied together at the corners and arranged in two sets of thirty-five kites each. Each of these kites was tested individually before being combined and found to fly well by itself. There are a total of 840 triangular cells in the giant kite. The total length of the kite is 29.5 feet. The picture shows the kite rising into the air.

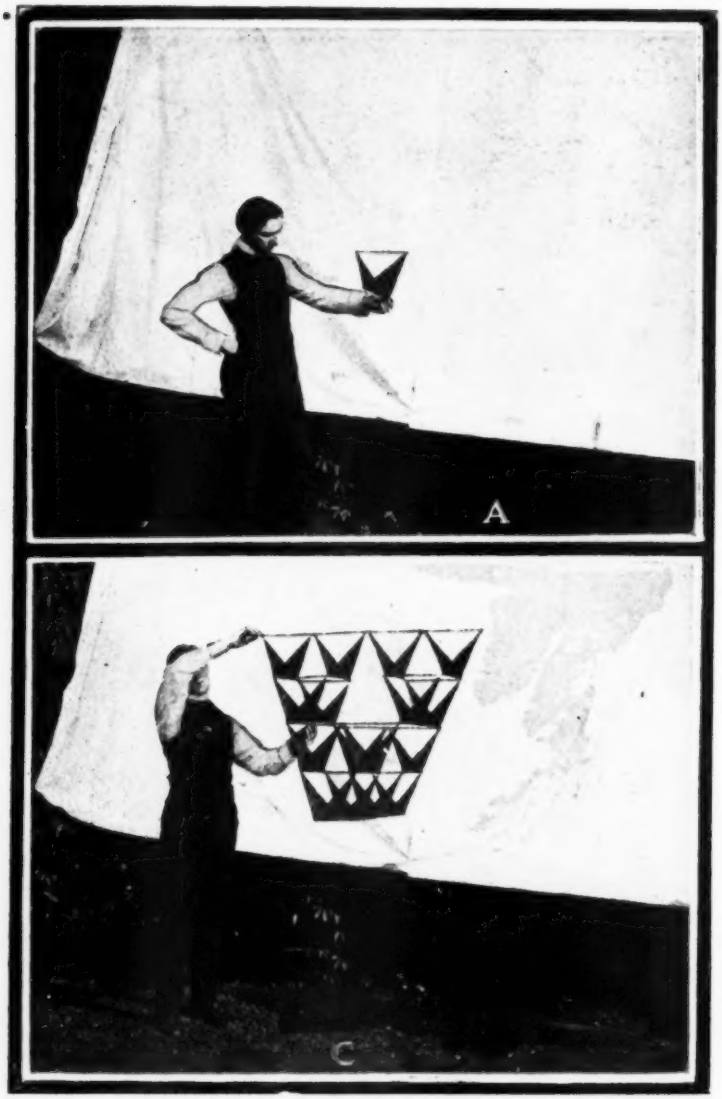
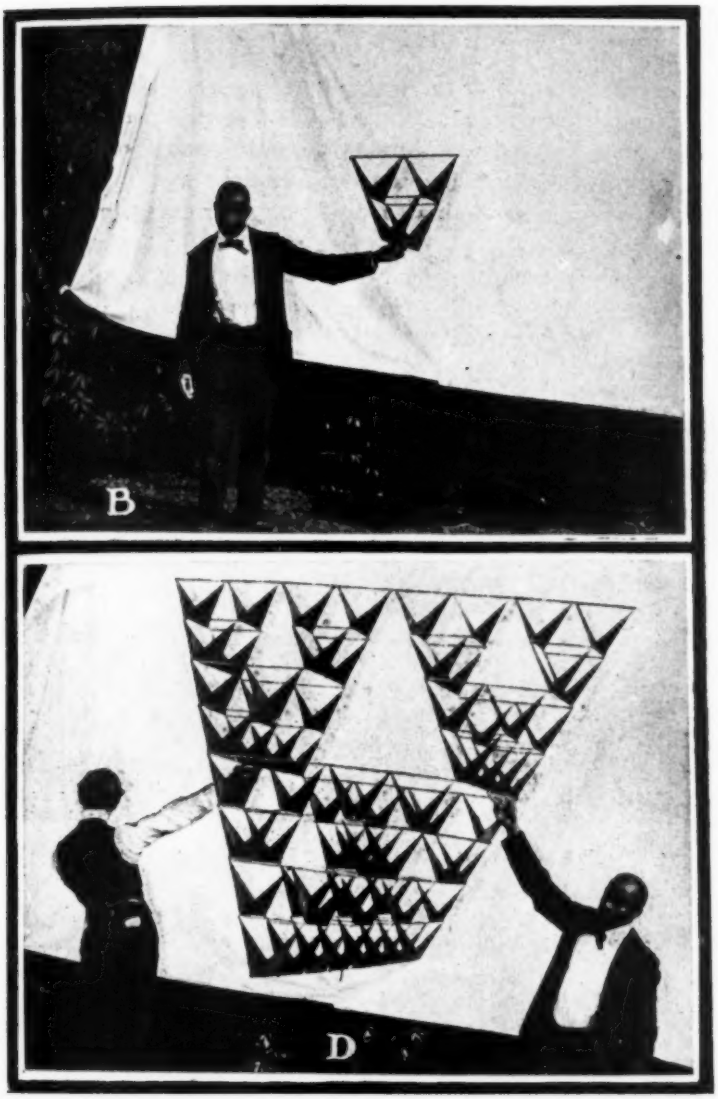


FIG. 3. *A*. A WINGED TETRAHEDRAL CELL.
C. A SIXTEEN-CELLED TETRAHEDRAL KITE.

THE METHOD OF BUILDING UP KITES WITH TETRAHEDRAL CELLS. The four-celled kite *B* weighs four times as much as one cell and has four times as much wing-surface; the sixteen-celled kite *C* has sixteen times as much weight and sixteen times as much wing-surface; and the sixty-four celled kite *D* has sixty-four times as much weight and sixty-four times as much

the efficiency nor the size of a kite could be increased by using many small Hargrave box cells instead of two large box cells.

The problem was then to invent a new cell, one that could be used in combination. Circular cells, polygonal cells of six, eight and



B. A FOUR-CELLED TETRAHEDRAL KITE.
D. A SIXTY-FOUR-CELLED TETRAHEDRAL KITE.

wing-surface. The ratio of weight to surface, therefore, is the same for the larger kites as for the smaller. In the middle of the kites there is an empty space, octahedral in form, which seems to have the same function as the space between the two cells of the Hargrave box kite. The tetrahedral kites that have the largest central spaces preserve their equilibrium best in the air.

twelve sides, and cells of various other shapes were devised, tried and thrown away.

Finally the triangular cell was hit upon. It immediately proved an immense advance over the rectangular Hargrave, being stronger

in construction, lighter in weight and offering less head resistance to the wind.

Diagram 2 shows a drawing of a kite built of two triangular cells. The triangular cell needs bracing in one direction only, on its flat surfaces; in a transverse direction it is self-braced, so that internal bracing, which causes head resistance, is unnecessary.

By tying a number of kites built of triangular cells corner to corner, as shown in Fig. 1, Dr. Bell was able to construct a giant kite, Fig. 2, in which the ratio of weight to wing surface is not much more than that of the smaller kites of which it is composed. Combinations of

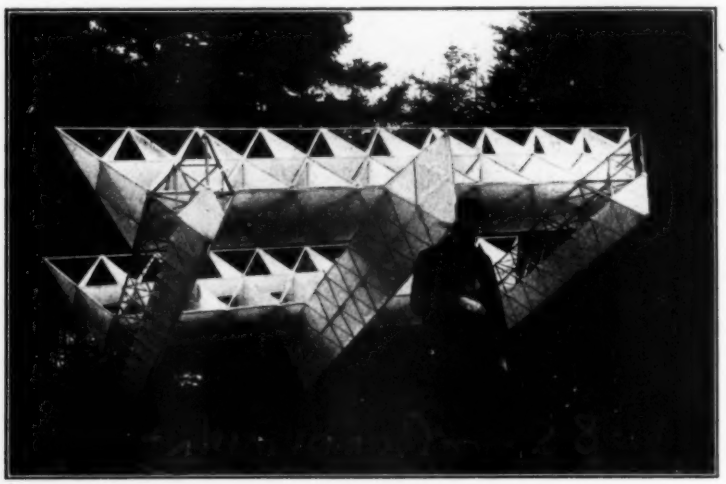


FIG. 4. FLOATING KITE BUILT OF TETRAHEDRAL CELLS.

triangular kites, however, must be arranged in two sets with a powerful connecting framework as shown in Fig. 2. The larger the two sets, the farther apart must they be, and, therefore, the connecting frame becomes exceedingly stout and heavy. This connecting framework is of course dead weight; it is a very serious handicap and soon limits the size of kites that can be built of triangular cells.

By his invention of the triangular cell Dr. Bell was able to build larger kites than he had been able to build before. The old limit of size was stretched considerably, but a limit remained none the less.

The principal improvements of the triangular cell, greater lightness and strength, are due to the cell being self-braced in a transverse direction, from side to side. Longitudinally, fore and aft, it is, however, very weak, like the box cell. Dr. Bell reasoned that a cell could be made self-bracing in every direction by making it triangular in all directions or tetrahedral in form.

Accordingly a number of regular tetrahedral cells, Diagram 3, were

built in the laboratory. The experiments made with these cells have given startling results:

First.—A tetrahedral cell has astonishing strength even when composed of very light wooden sticks. As Dr. Bell has expressed it: "It is not simply braced in two directions in space like a triangle, but in three directions like a solid. If I may coin a word, it possesses 'three-dimensional' strength; not 'two-dimensional' strength like a triangle, or 'one-dimensional' strength like a rod. It is the skeleton of a solid, not of a surface or a line."*

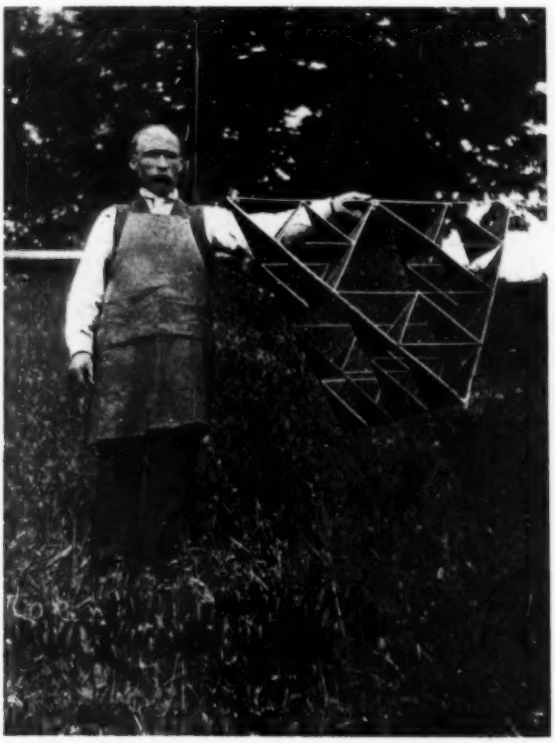


FIG. 5. SIXTEEN-CELLED TETRAHEDRAL KITE.

Second.—A large kite constructed of tetrahedral cells is as solid as a small one, for it is likewise self-braced in all directions.

Third.—A kite built of tetrahedral cells is an almost perfect flier; it is steady in squalls, a good 'lifter' and flys almost directly overhead. Tetrahedral cells when combined do not interfere with each other in the least or hurt each other's flying ability as box or triangular cells do when combined.

* 'The Tetrahedral Principle in Kite Structure.' By Dr. Alexander Graham Bell. *National Geographic Magazine*, June, 1903.

Fourth.—By the use of the tetrahedral cell it is possible to build kites unlimited in size and in which, however gigantic the kite, the ratio of supporting surface to weight remains the same as in a small kite.

The successive doubling in size of the kite shown in Fig. 3 may be carried on indefinitely without the weight increasing faster than the wing surface. The cells all act in harmony; no part of a kite built of tetrahedral cells has to be strengthened to counterbalance an opposing force or a weakness in some other part of the kite; no weight is thrown away.

By his invention of the regular tetrahedral winged cell, Dr. Bell thus got around the old law which said you can build kites up to a

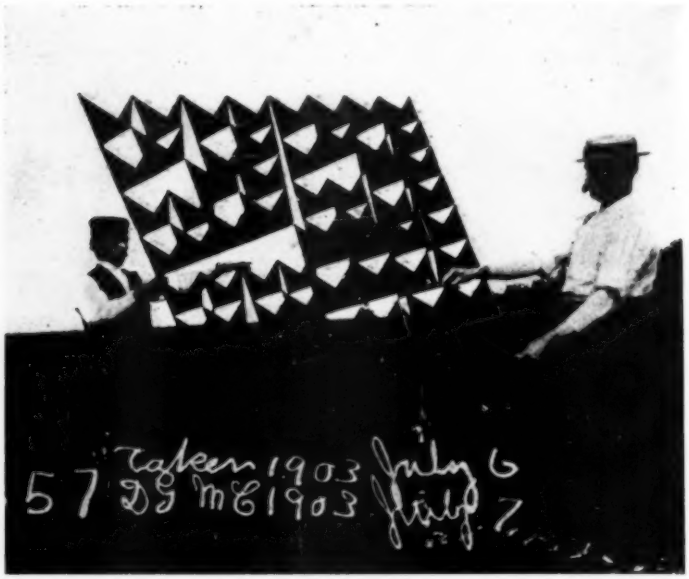


FIG. 6. SIXTY-FOUR CELLED KITE COMPOSED OF FOUR OF PRECEDING. 'RED FLIER.'

certain size, but no greater. The adherents of that law have always admitted that the law might be circumvented if a kite could be combined of many small models, but they have denied or at least doubted that a working combination of small models effective enough to carry a man, and to be called a flying machine, could be made. With his tetrahedral cell Dr. Bell has, however, been able to build kites of tremendous power, strong enough to carry up several men. One of his first kites lifted two men off their feet in a squall, and they only saved themselves from an undesirable ascent by instantly dropping the rope. Later this same kite (Fig. 4) snapped its rope, a three-eighth-inch new manila rope, as quickly as a thread. Kites much more power-

ful than this one have since been built and prove beyond a question that a practical, efficient and powerful method of combination of small forces has been discovered.

Dr. Bell has been building during the past summer thousands of tetrahedral cells varying in size from 25 cm. to 1 meter. Some of them are covered with light red silk weighing about 40 grams to the square meter and others with nainsook, very fine cotton, about as light as the silk. Some of the earlier cells were covered with cheesecloth, but the cheesecloth weighed so much—over 100 grams to the square meter—that Dr. Bell has discarded it. The framework of the cells is usually of black spruce, which is light and strong.

To make a tetrahedral cell, take six sticks of equal length and place three of them on a table so as to make an equilateral triangle. Erect one of the three remaining sticks at each corner of the triangle and bring the tops together. It is the old-fashioned puzzle of making four triangles with six matches. Then cover any two sides and you have a tetrahedral winged cell.

FIG. 7. 'RED FLIER' IN THE AIR.

A number of cells outlined against the sky look like a flock of birds; for instance look at Fig. 18; the wings of a cell are also like a bird's wings in that they are not rigid like a board; the silk covering yields somewhat to the pressure of the wind as the feathers of a bird's wing.

Hundreds of tetrahedral cells are now being made in which the frame consists of hollow aluminum tubing. The aluminum weighs very little more than the spruce wood hitherto employed and gives much greater strength to the frame.

Using these cells just as a mason uses bricks to build houses of many forms, he has been constructing kites of every shape that a fertile brain could devise. Steadiness in the air and lifting power have been the main object in all. Some of his combinations are gigantic, exceeding twenty-five feet in length and twelve and fifteen feet in height and width, but in spite

of their strength all are so light that his trained assistants send the giant kites up into the air as easily as the little fellows.

The kite shown in Fig. 5 is tetrahedral in form and built of sixteen tetrahedral cells. This was the first tetrahedral kite constructed by Dr. Bell. It is a wonderful flier, darting up from the ground with a shrill whistle and climbing to extraordinary heights. It is a pretty sight to see the operator bring the kite in after the experiment is over.

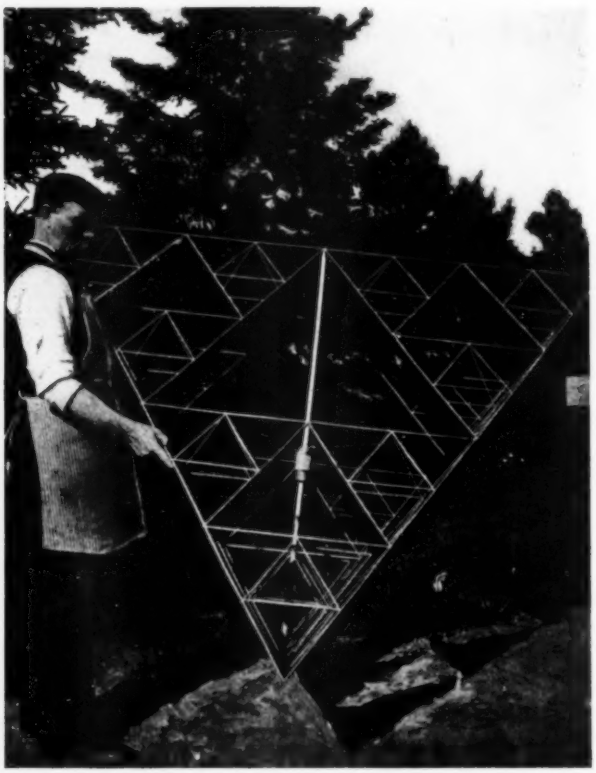


FIG. 8. SIXTEEN LARGE-CELLED KITE CARRYING FIVE POUNDS OF LEAD.

The kite flies steadily without a turn or quiver as the line is reeled in and finally alights on his hand as gently as a bird. Figs. 6 and 7 show a sixty-four-celled kite made of four kites like the preceding. The kite is two meters on a side. The most remarkable feature of this kite, aside from its perfect equilibrium and steadiness in squalls, is its ability to fly almost directly overhead. Even in the lightest breeze I have rarely seen it flying at an angle of less than eighty degrees. The kite is admirably adapted for meteorological observations at great heights, as it can carry considerable weight with the greatest ease. Fig. 8 shows a kite of the same size but with sixteen cells instead of

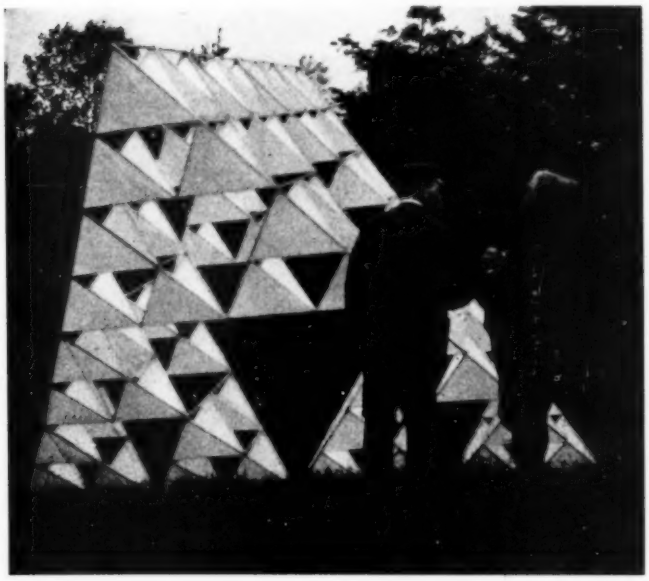


FIG. 9. SIXTY-FOUR CELLED WHITE FLIER RESTING ON ITS KEEL.

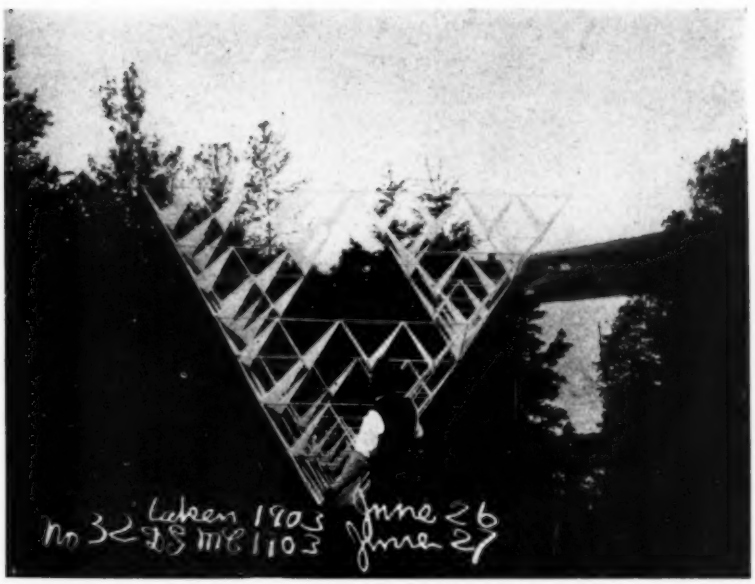


FIG. 10. WHITE FLIER. (FRONT VIEW.)

sixty-four, the cells being four times as large. The kite is not as successful as the preceding one. Dr. Bell's experiments have convinced him that the small cells are better; when the wind varies in strength as in a squall, the shifting of pressure on a small cell is less than the shifting on a large cell; hence the resultant shifting of pressure on a kite built of small cells is considerably less than on a kite built of large cells. Fig. 8 shows the method of attaching five pounds, a piece of lead in this case; the kite is not disturbed by the weight. The kite

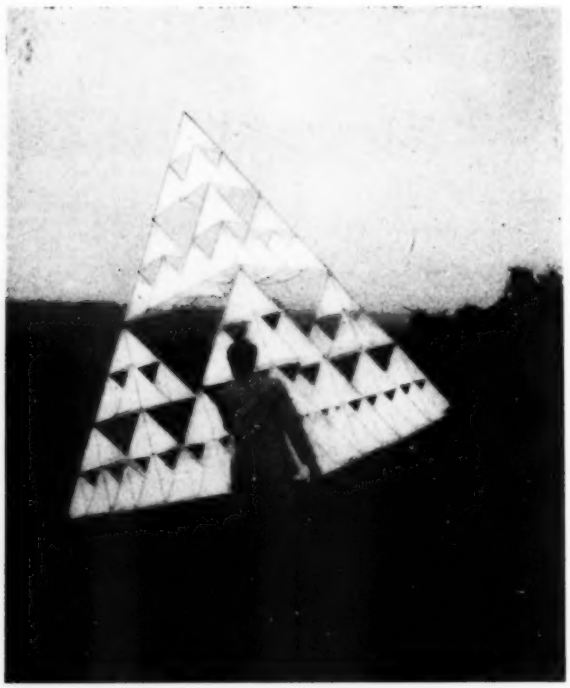


FIG. 11. WHITE FLIER. CARRYING IT OFF THE FIELD AFTER THE EXPERIMENT.

shown in Figs. 9, 10 and 11 is also tetrahedral in form and built of tetrahedral cells. It is twice as large as the red flier, being four meters on a side. Fig. 9 gives a side view and Fig. 10 a front view of the kite as it rests on its keel. The average pull of this kite in light winds is 80 pounds; in a heavy wind it exceeds 150 pounds.

The strength of the kites made of tetrahedral cells is something remarkable. I have seen one of these kites towed on a tetrahedral float for more than a mile on the bay at a speed of eleven or twelve knots without breaking, though one end was dragging one foot under water all the time. As I saw the kite pulled along I expected to see it

shattered to pieces, but beyond a few broken sticks it was as well and strong at the end of the journey as when it started.

The big tetrahedral kites, twelve feet and more on a side, look like awkward things to travel with or to store away, but they may be packed as handily and in as small compass as blankets or rugs. Each kite is made in collapsible sections, which open and then fold up, as shown in Fig. 12. Half a dozen large kites can in this way be carried in a trunk from place to place and put together in a few minutes.

The more recent experiments made have been to obtain a giant manlifting kite, or flying machine, that will rise from the surface of a lake. Any one who has ever watched a heavy bird rise from the ground has doubtless noticed that it runs along the ground for a few feet before it rises—the bird must acquire some momentum before its wings can lift its heavy body into the air. The natives of certain parts of the Andes understand this fact very well and by means of it catch the great Andean vultures. A small space is shut in with a high fence and left open at the top. Then a lamb or piece of carrion is placed on the ground inside. Presently a vulture sees the bait and swoops down upon it; but when once he has lighted on the ground inside he can not get out for he has no running space in which to acquire the momentum that is necessary before his wings can lift him. In the same way the first difficulty of all flying machines is to acquire the first momentum that will lift the machine into the air. To overcome this difficulty the flying machine inventor usually shoots his machine from a high platform which makes it necessary for the machine to rise immediately. But if the flying machine can not start in a natural way the chances are its method of working is not right and it is doomed to failure. And even if a machine could fly perfectly after it had been started how could it get up again if it came down for food or fuel at some point where there was no platform and starting

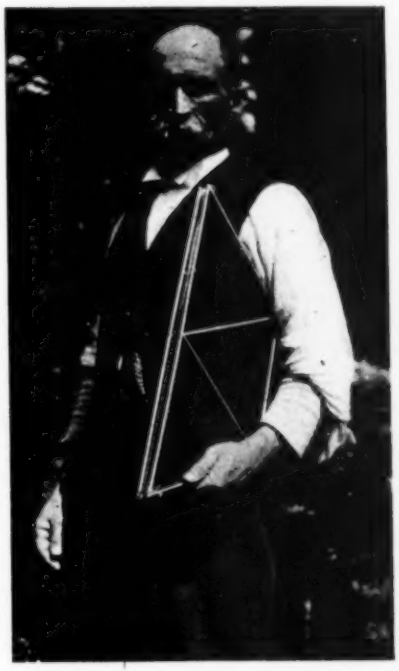


FIG. 12. A SECTION OF A KITE FOLDED UP FOR PACKING.

apparatus? In a word the solution to the whole flying machine problem is to get a machine that will start of itself without being shot off as if from the mouth of a cannon. The successful machine in rising will probably have to imitate the start of a large and heavy bird—that is glide along the ground or surface of a lake for some distance with constantly increasing speed until it rises of its own momentum.

A little kite, such as that shown in Fig. 5, darts up from the hand if there is the least breath stirring. The larger kite, shown in Figs. 6 and 7, is equally nimble, but in a faint breeze, to raise the large White Flier, shown in Figs. 9 and 10 and which is more than twelve feet on a side, the operator has to run a few yards towing the kite behind him.

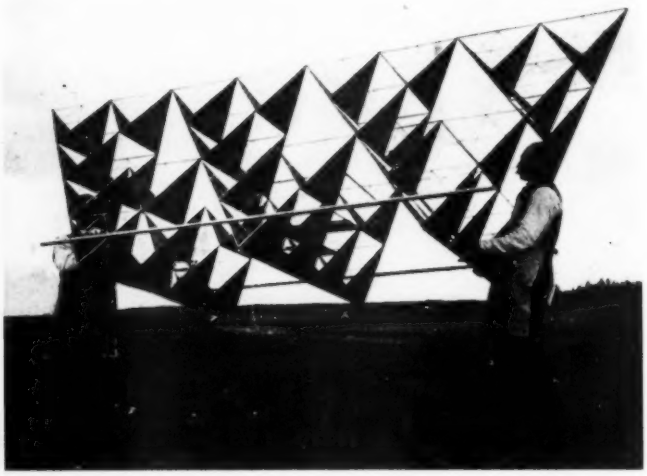


FIG. 13. MODEL OF MABEL II.

Kites larger than the White Flier Dr. Bell sends skyward by tying the rope to the collar of a fast horse and then sending the steed galloping down the field. Of course, when a good wind blows all these kites soar upward as easily as the little fellow.

But to raise the giant kite Mabel II., shown in Fig. 15, Dr. Bell found a more serious problem. It would be difficult for a man or horse to pull the great frame so steadily as to keep her from being dashed against the ground and smashed before she could rise.

The kite has power enough to lift several men, but how was Dr. Bell to get her up into the air? If he could raise Mabel II. naturally, like one of the smaller kites, he could be pretty sure that she would go up when a motor, with propellers, was suspended to her. A pull or a push would be identical in its effect. In a word, if Dr. Bell could get this great man-lifting kite into the air by towing, as he did the

smaller kites, he would succeed in obtaining a successful form for a flying machine.

There are two ways in which Mabel II. might be towed—on wheels along a track or on floats on the surface of a lake. Dr. Bell preferred to try the second method first, as it is simpler and easier.

With tetrahedral frames he built three long boats and covered them with oilcloth to make them watertight. The boats possess great strength, and yet, because of their tetrahedral structure, are so light as not to overweight the kite. The three boats were then ranged parallel to one another and the whole structure placed upon and securely fastened to them.

FIG. 14. TESTING ONE OF THE BOATS OF MABEL II.

Fig. 15 shows Mabel II., just before she was launched. This figure and Figs. 16 and 17 give an excellent idea of the construction of the kite. Across the floats extend two bridges, built of tetrahedral cells. Resting on the bridges are four large kites, like the one shown in Fig. 8. The spaces between the four kites are filled with smaller tetrahedral cells. In all there are 272 cells in the structure.

Fig. 18 shows the kite floating merrily on the water waiting to be put to the test. With her tiers of red wings above and white wings below she was a beautiful sight. But would she fly? A small model of Mabel II., shown in Fig. 13 had flown beautifully on land. The flying weight of this model was greater than the flying weight of Mabel II., and Dr. Bell had therefore every reason to believe that Mabel II. would also fly if he could raise her.

When everything was ready Mabel II. was towed out to the center of the bay and her flying line cast aboard the steamer which Dr. Bell had engaged for the experiment. The flying line was made fast to a cleat on deck and the steamer started ahead at full speed, twelve or thirteen knots an hour.

But Mabel II. was working under two bad handicaps—first, a

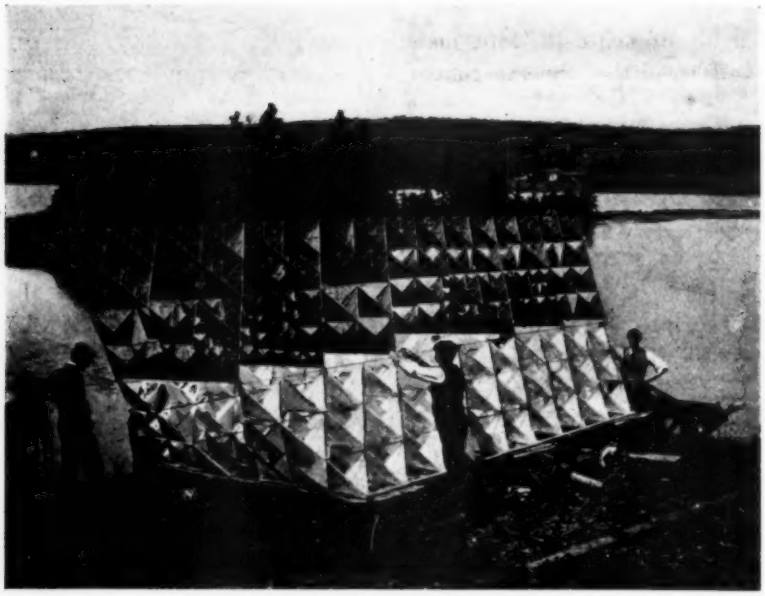


FIG. 15. MABEL II. BEFORE LAUNCHING.

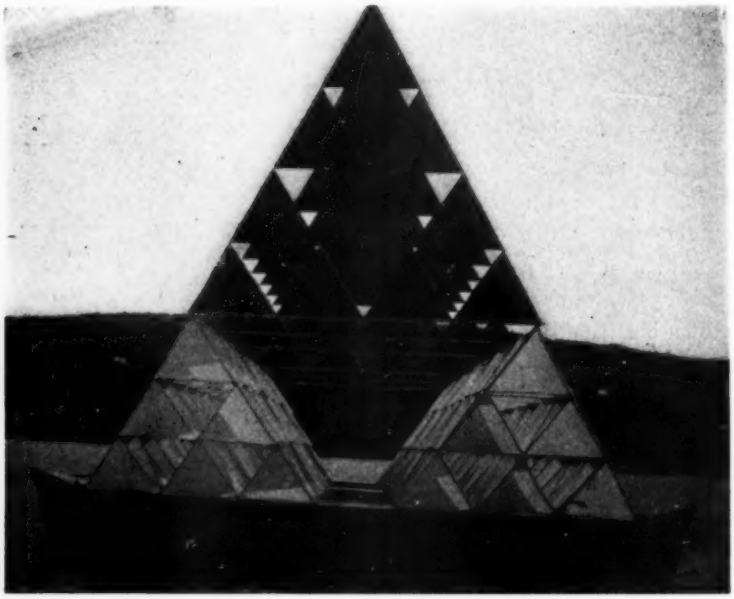


FIG. 16. END VIEW OF MABEL II.

heavy downpour had begun some minutes before the start and had thoroughly drenched the kite, making her so heavy that every one but Dr. Bell urged that the experiment be postponed (when Mabel II. was

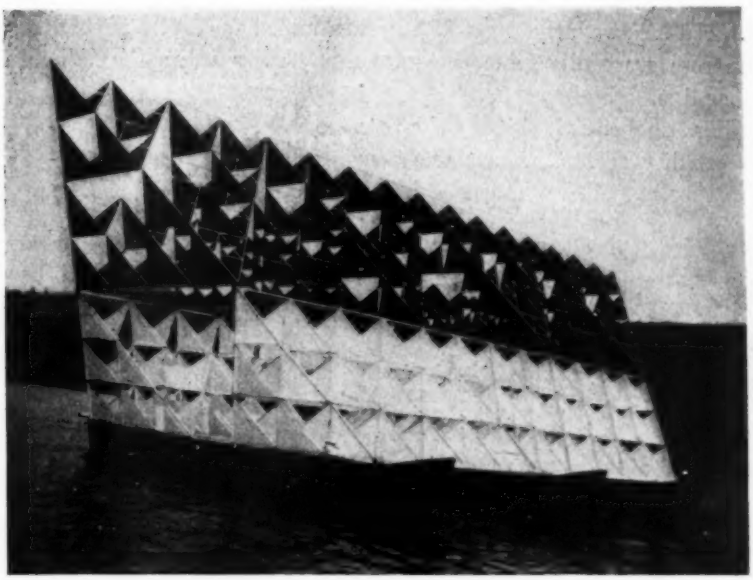


FIG. 17. FRONT VIEW OF MABEL II.

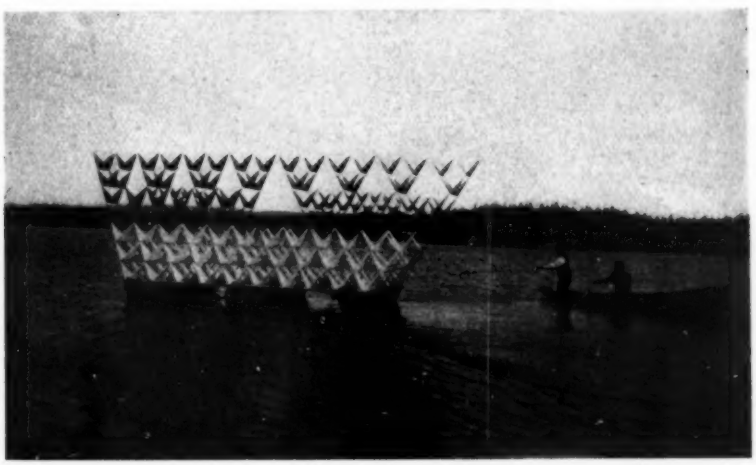


FIG. 18. MABEL II. OUTLINED AGAINST SKY SHOWING BIRD-WING EFFECT.

weighed after the experiment it was found that the rain water and leakage in the boats had increased her weight by sixty-four pounds); second, the operator on the deck of the steamer had given Mabel II.

too short a line, so that she was blanketed by the big hull of the steamer and therefore received but a small fraction of the wind of motion.

In spite of these two serious disadvantages, however, as the steamer gathered headway, the great kite first trembled for a few moments, and then rose gracefully from the water and flew steadily the full length of her line.

Fig. 19 shows the kite as she rose from the water after being towed a short distance. The rain was pouring down in such torrents at the time that my other pictures were not successful.

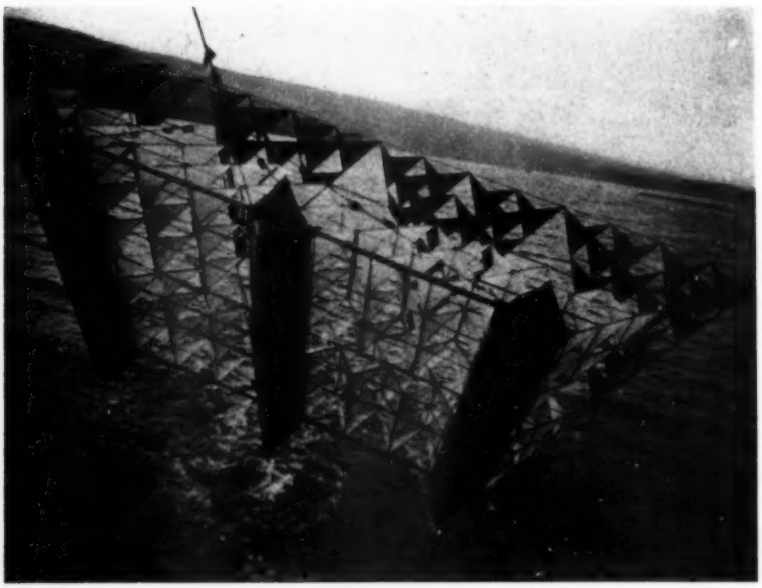


FIG. 19. MABEL II. RISING INTO THE AIR.

The experiment was thus a success, and showed conclusively that Dr. Bell has obtained a man-lifting kite, or flying machine, that will rise of itself. If a pull will make the kite rise, there is no reason to doubt that an equally powerful push, such as propellers would give, would be equally successful in causing the kite to ascend.

Though the tests have proved that Mabel II. can easily carry a man and engine, no actual ascents have been made this summer. When ascensions are made the man will sit in the center of the open space between the two bridges (see Fig. 16).

One of the beauties of Dr. Bell's models is that in every one there is a large roomy space in the center where the operator and his passengers can sit. This position is much safer and more comfortable than

sitting in a chair suspended some yards below the machine. As the ultimate machine will probably be of tougher material than wood and silk, in time of war the operator and the motor would be protected as well as hidden, instead of being a splendid target for every shot from below.

Kites that are tetrahedral in form, as the red and white fliers shown in Figs. 6 and 9 and those used to form the superstructure of Mabel II., have perfect equilibrium, but because of their small resultant area of horizontal or sustaining surface, their lifting power, though considerable, is not as great as Dr. Bell is satisfied to obtain. His latest combinations have, therefore, been made in the hope of obtaining greater horizontal surface, and thus greater lifting power. In Figs. 21 and 22 is shown a new form of kite, Victor I., which is undoubtedly the most wonderful kite ever devised and put together.

FIG. 20. MODEL OF MABEL II. IN AIR.

This great H-shaped kite rose from the hand, without running, in a breeze so light that a flag on a pole fifty yards away hung limp and motionless. It glided up and up until it was flying six or seven hundred yards high, steady as a table top. The breeze at that elevation was perhaps five or six miles, though on the ground the movement of the air was so light as to be imperceptible even on the grass or trees. In a breeze of fifteen miles it flew as steadily as before, but nearer the perpendicular and with a tremendous pull.

A glance at the photographs will readily explain what makes the kite such a remarkable flier. The cells of the two wings are reversed, the keels of the cells pointing up instead of down, and the tips pointing down instead of up, while above each tier of cells stretches a wide aeroplane. This wide expanse of sustaining surface helps the winged cells tremendously and at the same time does not interfere with their working. Victor I. is three meters long, three meters wide and one meter deep and weighs only twelve pounds. The flying weight is only three hundred and fifty grams to the square meter of horizontal surface. A smaller kite of similar model has been constructed whose flying weight is about two hundred grams.

The wonderful lightness of this model will be better understood when we realize that it carries twenty-five square feet of supporting or horizontal wing surface to one pound of weight, while a wild duck

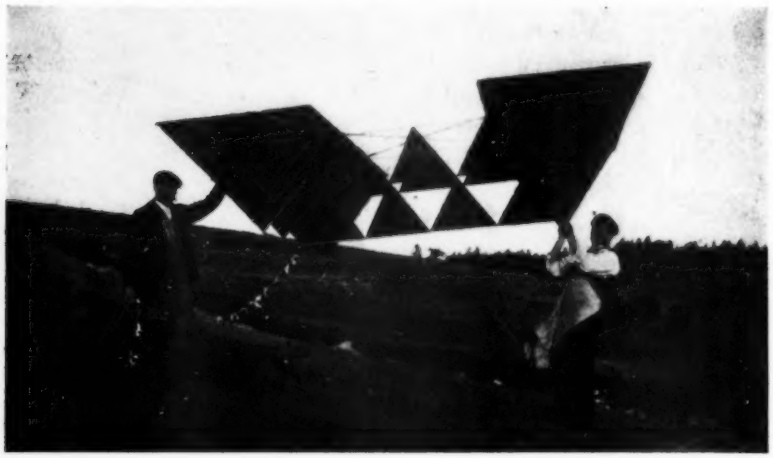


FIG. 21. VICTOR I.

has only one half of one square foot of wing surface to one pound of weight. The model almost rivals a mosquito in lightness—one pound of mosquitoes represents an area of wing surface of forty-nine square feet.

FIG. 22. END VIEW OF ONE OF THE CELLS OF VICTOR I.

Dr. Bell is now making a wind boat on this model, and it would not be surprising if this new wind boat should eclipse even the redoubtable Mabel II.

The framework of this latest model is also strong enough to support a man, and yet its flying weight is, as I have said, only 200 grams to the square meter of supporting surface. When we consider that the flying weight of other machines in which the greatest lightness has been striven for is nearly one hundred times as great as in this kite, we realize the tremendous advance made by Dr. Bell in at least one direction—a marvelous combination of lightness and strength.

In not one of the successful kites of Dr. Bell has the flying weight exceeded 500 grams to the square meter of supporting surface, whereas in various other machines the ratio exceeds 10,000 grams to the square meter.

Dr. Bell has thus constructed one form of successful flying machine, Mabel II. Another form, which may be even more successful and of which Victor I. is a model, is nearly completed. To obtain the form of a flying machine has been the principal problem to solve; the matter of a motor is comparatively simple.

The next step is to place a motor on Mabel II., or an enlarged Victor I., with a propeller extending from each side of the kite like an aerial paddle wheel. Strong and light motors are in the market and to be had easily. Then, as the operator sits inside with spinning propellers he can drive the kite up and down the surface of the bay testing how to control and steer her. Later, with the propellers going faster, he can send the kite skimming along a few yards above the surface and continue the experiments at this small height above the water without danger to life.

Finally, by still further increasing the speed of his propellers he can shoot upward and leisurely proceed wherever he may desire. Great speed is not Dr. Bell's object. Ten or fifteen miles an hour is enough to start with.

Dr. Bell has now reached the point where the flying machine is no longer problematical. It is simply a question of time necessary to put things together. Whether the first flying machine carrying a man is built by him at his laboratory in Beinn Bhreagh is probably immaterial to him, but the chances are that if some one else does not build a successful machine within the next year or two he will have a flying machine of his own by that time.*

* Figures 1–8, 10, 12, 13, 14, 15 and 20 are from photographs by Mr. David George McCurdy, the photographer of Dr. Bell's laboratory; the photographs shown in Figures 9 and 11 and those of Mabel II. and Victor I. were taken by the author.

HERTZIAN WAVE WIRELESS TELEGRAPHY, VII.

By Dr. J. A. FLEMING,
PROFESSOR OF ELECTRICAL ENGINEERING, UNIVERSITY COLLEGE, LONDON.

A NUMBER of more or less imperfect arrangements, having the isolation of communications for their object, have been devised or patented, which are dependent upon the use of several aerials, each supposed to be responsive only to a particular frequency; and attempts have been made to solve the problem of isolation by MM. Tommasi, Tesla, Jegon, Tissot, Ducretet and others.

We may then pass on to notice the attempts that have been made to secure isolation by a plan which is not dependent on electrical syntony. One of these, which has the appearance of developing into a practical solution of the problem, is that due to Anders Bull.* In the first arrangements proposed by this inventor, a receiver is constructed which is not capable of being acted upon merely by a single wave or train of waves or even a regularly spaced train of electric waves, but only by a group of wave trains which are separated from one another by certain unequal, predetermined intervals of time. Thus, for instance, to take a simple instance, the transmitting arrangements are so devised as to send out groups of electric waves, these wave trains following one another at time intervals which may be represented by the numbers 1, 3 and 5; that is to say, the interval which elapses between the second and third is three times that between the first two, and the interval between the fourth and fifth is five times that between the first two. This is achieved by making five electric oscillatory sparks with a transmitter of the ordinary kind, the intervals between which are settled by the intervals between holes punched upon strips of paper, like that used in a Wheatstone automatic telegraphic instrument. It will easily be understood that by a device of this kind, groups of sparks can be made, say five sparks rapidly succeeding each other, but not at equal intervals of time. One such group constitutes the Morse dot, and two or three such groups succeeding one another very quickly constitute the Morse dash. These waves, on arriving at the receiving station, are caused to actuate a punching arrangement by the intermediation of a coherer or other kumascope, and to punch upon a uniformly moving strip of paper holes, which are at intervals of time corresponding to the intervals between the sparks at the transmitting station. This strip of paper then passes through another telegraphic instrument, which is so constructed that it prints upon another strip

* See *The Electrician*, Vol. XLVI., p. 573, February 8, 1901.

a dot or a dash, according to the disposition of the holes on the first strip. Accordingly, taken as a whole, the receiving arrangement is not capable of being influenced so as to print a telegraphic sign except by the operation of a series of wave trains succeeding one another at certain assigned intervals of time.

An improvement has been lately described by the same inventor* in which the apparatus used, although more complicated, performs the same functions. At each station two instruments have to be employed; at the transmitting station one to effect the conversion of Morse signals into the properly arranged series of wave trains, and at the receiving station an instrument to effect the reconversion of the series of wave trains into the Morse signals. These are called respectively the dispenser and the collector. The details of the arrangements are somewhat complicated and can only be described by the aid of numerous detailed drawings, but the inventor states that he has been able to carry on Hertzian wave telegraphy by means of these arrangements for short distances. Moreover, the method lends itself to an arrangement of multiplex telegraphy, by sending out from different transmitters signals which are based upon different arrangements of time intervals between the electric wave trains. Although this method may succeed in preventing a receiving arrangement from being influenced by vagrant waves or waves not intended for it, yet an objection which arises is that there is nothing to prevent any one from intercepting these wave trains, and with a little skill interpreting their meaning. Thus, if the record were received in the ordinary way on a simple receiver, corresponding to a Morse dot would be printed five dots at unequal intervals, and corresponding to a Morse dash would be printed two such sets of five dots. A little skill would then enable an operator to interpret these arbitrary signals. On the other hand, the inventor asserts that he can overcome this difficulty by making intervals of time between the impulses in the series so long that the latter become longer than the intervals between each of the series of waves which are dispatched in continuous succession when the key is pressed for a dash. In this case, when telegraphing, the series of dots would overlap and intermingle with each other in a way which would make the record unintelligible if received in the usual manner, but would be perfectly legible if received and interpreted by a receiver adapted for the purpose.

Another way of obliterating the record, as far as outsiders are concerned, is to interpolate between the groups of signals an irregular series of dots, *i. e.*, of wave trains, which would affect an ordinary coherer, and so make an unintelligible record on an ordinary receiver,

* See *Electrician*, Vol. I., p. 418, January 2, 1903.

but these dots are not received or picked up by the appropriate selecting instrument used in the Anders Bull system.

The matter most interesting to the public at the present time is the long distance telegraphy by Hertzian waves to the accomplishment of which Mr. Marconi has devoted himself with so much energy of late years. Every one, except perhaps those whose interests may be threatened by his achievements, must accord their hearty admiration of the indomitable perseverance and courage which he has shown in overcoming the immense difficulties which have presented themselves. Five years ago he was engaged in sending signals from Alum Bay, in the Isle of Wight, to Bournemouth, a distance of twelve or fourteen miles; and to-day he has conquered twice that number of hundred miles and succeeded in sending, not merely signals, but long messages of all descriptions over three thousand miles across the Atlantic. Critics there are in abundance, who declare that the process can never become a commercial one, that it will destroy short distance Hertzian telegraphy, or that the multiplication of long distance stations will end in the annihilation of all Hertzian wave telegraphy. No one, however, can contemplate the history of any development of applied science without seriously taking to heart the lesson that the obstacles which arise and which prove serious in any engineering undertaking are never those which occur to armchair critics. Sometimes the seemingly impossible proves the most easy to accomplish, whilst difficulties of a formidable nature often spring up where least expected.

The long distance transmission is a matter of peculiar interest to the author of these articles, because he was at an early stage in connection with it invited to render Mr. Marconi assistance in the matter.* The particular work entrusted to him was that of planning the electrical engineering arrangements of the first power station erected for the production of electric waves for long distance Hertzian wave telegraphy at Poldhu, in Cornwall. When Mr. Marconi returned from the United States in the early part of 1900, he had arrived at the conclusion that the time had come for a serious attempt to accomplish wireless telegraphy across the Atlantic. Up to that date the project had been an inventor's dream, much discussed, long predicted, but never before practically taken in hand. The only appliances, moreover, which had been used for creating Hertzian waves were induction coils or small transformers, and the greatest distance covered, even by Mr. Marconi himself, had been something like 150 miles over sea. Accordingly, to grapple with the difficulty of creating an electric wave capable of making itself felt at a distance of 3,000 miles, even with the delicate receiving appliances invented by Mr. Marconi, seemed to require the

* See Mr. Marconi's Friday evening discourse at the Royal Institution, June 13, 1902; also *The Electrician*, Vol. XLIX., p. 390.

means of producing at least four hundred times the wave-energy that had been previously employed. The author was therefore requested to prepare plans and specifications for an electric generating plant for this purpose, which would enable electrical oscillations to be set up in an aerial on a scale never before accomplished.

This work involved, not merely the ordinary experience of an electrical engineer, but also the careful consideration of many new problems and the construction of devices not before used. Every step had to be made secure by laboratory experiments before the responsibility could be incurred of advising on the nature of the machinery and appliances to be ordered. Many months in the year 1901 were thus occupied by the author in making small scale experiments in London and in superintendence of large scale experiments at the site of the first power station at Poldhu, near Mullion, in Cornwall, before the plant was erected and any attempt was made by Mr. Marconi to commence actual telegraphic experiments. As this work was of a highly confidential nature, it is obviously impossible to enter into the details of the arrangements, either as made by the writer in the first instance, or as they have been subsequently modified by Mr. Marconi. The design of the aerial and of the oscillation transformers and many of the details in the working appliances are entirely due to Mr. Marconi, but as a final result, a power plant was erected for the production of Hertzian waves on a scale never before attempted. The utilization of 50 or 100 H.P. for electric wave production has involved dealing with many difficult problems in electrical engineering, not so much in novelty of general arrangement as in details. It will easily be understood that Leyden jars, spark balls and oscillators, which are quite suitable for use with an induction coil, would be destroyed immediately if employed with a large alternating current plant and immensely powerful transformers.

In the initial experiments with this machinery and in its first working there was very considerable risk, owing to its novel and dangerous nature; but throughout the whole of the work from the very beginning, no accident of any kind has taken place, so great have been the precautions taken. The only thing in the nature of a mishap was the collapse of a ring of tall masts, erected in the first place to sustain the aerial wires, but which have now been replaced by four substantial timber towers, 215 feet in height, placed at the corners of a square 200 feet in length. These four towers sustain a conical arrangement of insulated wires (see Fig. 26) which can be used in sections and which constitute the transmitting radiator or receiver, as the case may be. Each of these wires is 200 feet in length and formed of bare stranded wire.

At the outset, there was much uncertainty as to the effect of the curvature of the earth on the propagation of a Hertzian wave over a distance of many hundreds of miles. In the case of the Atlantic transmission between the station at Poldhu in Cornwall and that at Cape Cod in Massachusetts, U. S. A., we have two stations separated by about

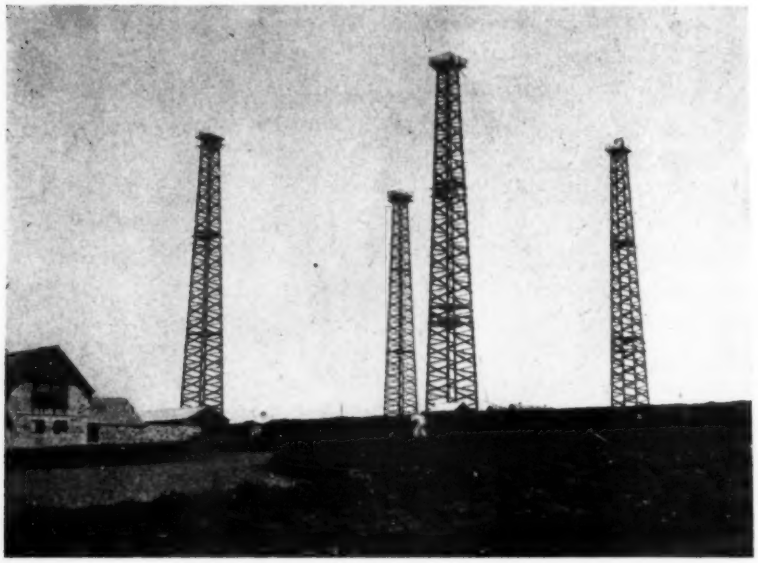


FIG. 26. WOODEN TOWERS SUPPORTING THE MARCONI AERIAL AT POLDHU POWER STATION, CORNWALL, ENGLAND.

45 degrees of longitude on a great circle, or one eighth part of the circumference of the world. In this case, the versine of the arc or height of the sea at the halfway point above the straight line or chord joining the two places is 300 miles.

This question has recently attracted the attention of several eminent mathematical physicists. The extent to which a free wave propagated in a medium bends round any object or is diffracted depends on the relation between the length of the wave and the size of the object. Thus, for instance, an object the size of an orange held just in front of the mouth does not perceptibly interfere with the propagation of the waves produced by the speaking or singing voice, because these are from two to six feet in length; but if arrangements are made by means of a Galton whistle to produce air waves half an inch in length, then an obstacle the size of an orange causes a very distinct acoustic shadow. The same thing is true of waves in the ether. The amount of bending of light waves round material objects is exceedingly small, because the average length of light waves is about one fifty-thousandth part of an

inch. In the case of Hertzian wave telegraphy, we are, however, dealing with ether waves many hundreds of feet in length, and the waves sent out from Poldhu have a wave-length of a thousand feet or more, say one fifth to one quarter of a mile. The distance therefore between Poldhu and Cape Cod is only at most about twelve thousand wave-lengths, and stands in the same relation to the length of the Hertzian wave used as does a body the diameter of a pea to the wave-length of yellow light. There is unquestionably a large amount of diffraction or bending of the electric wave round the earth, and proportionately speaking it is larger than in the case of light waves incident on objects of the same relative size.

Quite recently Mr. H. M. Macdonald (see *Proc. Roy. Soc. Lond.*, Vol. LXXI., p. 251) has submitted the problem to calculation, and has shown that the power required to send given electric waves 3,000 miles along a meridian of the earth is greater than would be required to send them over the same distance if the sea surface were flat in the ratio of 10 to 3. Hence the rotundity of the earth does introduce a very important reduction factor, although it does not inhibit the transmission. Mr. Macdonald's mathematical argument has, however, been criticized by Lord Rayleigh and by M. H. Poincaré (see *Proc. Roy. Soc.*, Vol. 72, p. 40, 1903).

The accomplishment of very long distances by Hertzian wave telegraphy is, however, not merely a question of power, it is also a question of wave-length. Having regard, however, to the possibility that the propagation which takes place in Hertzian wave telegraphy is not that simply of a free wave in space, but the transmission of a semi-loop of electric strain with its feet tethered to the earth, it is quite possible that if it were worth while to make the attempt, an ether disturbance could be made in England sufficiently powerful to be felt in New Zealand.

Leaving, however, these hypothetical questions and matters of pure conjecture, we may consider some of the facts which have resulted from Mr. Marconi's long distance experiments. One of the most interesting of these is the effect of daylight upon the wave propagation. In one of his voyages across the Atlantic, when receiving signals from Poldhu on board the S. S. *Philadelphia*, he noticed that the signals were received by night when they could not be detected by day.* In these experiments Mr. Marconi instructed his assistants at Poldhu to send signals at a certain rate from 12 to 1 A. M., from 6 to 7 A. M., from 12 to 1 P. M. and from 6 to 7 P. M., Greenwich mean time, every day for a week. He has stated that on board the *Philadelphia* he did not

* See *Proc. Roy. Soc.*, June 12, 1902. 'A note on the Effect of Daylight upon the Propagation of Electromagnetic Impulses Over Long Distances,' by G. Marconi.

notice any apparent difference between the signals received in the day and those received at night until after the vessel had reached a distance of 500 statute miles from Poldhu. At distances of over 700 miles, the signals transmitted during the day failed entirely, while those sent at night remained quite strong up to 1,551 miles, and were clearly decipherable up to a distance of 2,099 miles from Poldhu. Mr. Marconi also noted that at distances of over 700 miles, the signals at 6 A. M., in the week between February 23 and March 1, were quite clear and distinct, whereas by 7 A. M. they had become weak almost to total disappearance. This fact led him at first to conclude that the cause of the weakening was due to the action of the daylight upon the transmitting aerial, and that as the sun rose over Poldhu, so the wave energy radiated, diminished, and he suggested as an explanation the known fact of the dissipating action of light upon a negative charge.

Although the facts seem to support this view, another explanation may be suggested. It has been shown by Professor J. J. Thomson that gaseous ions or electrons can absorb the energy of an electric wave, if present in a space through which waves are being transmitted.* If it be a fact, as suggested by Professor J. J. Thomson, that the sun is projecting into space streams of electrons, and if these are continually falling in a shower upon the earth, in accordance with the fascinating hypothesis of Professor Arrhenius, then that portion of the earth's atmosphere which is facing the sun will have present in it more electrons or gaseous ions than that portion which is turned towards the dark space, and it will therefore be less transparent to long Hertzian waves.† In other words, clear sunlit air, though extremely transparent to light waves, acts as if it were a slightly turbid medium for long Hertzian waves. The dividing line between that portion of the earth's atmosphere which is impregnated with gaseous ions or electrons is not sharply delimited from the part not so illuminated, and there may be therefore a considerable penetration of these ions into the regions which I may call the twilight areas. Accordingly, as the earth rotates, a district in which Hertzian waves are being propagated is brought, towards the time of sunrise, into a position in which the atmosphere begins to be ionized, although far from as freely as is the case during the hours of bright sunshine.

Mr. Marconi states that he has found a similar effect between inland

* See *Phil. Mag.*, Vol. IV., p. 253. Series 6, August, 1902. J. J. Thomson, 'On Some Consequences of the Emission of Negatively Electrified Corpuscles by Hot Bodies.'

† The opinion that ionization of the air by sunlight is a cause of obstruction to Hertzian waves propagated over long distances has also been expressed by Mr. J. E. Taylor. See *Proc. Roy. Soc.*, Vol. LXXI., p. 225, 1903. 'Characteristics of Earth Current Disturbances and their Origin.'

stations, signals having been received by him during the night between Poldhu and Poole with an aerial the height of which was not sufficient to receive them by day. It has been found, however, that the effect simply amounts to this, that rather more power is required by day than by night to send signals by Hertzian waves over long distances.

Some interesting observations have also been made by Captain H. B. Jackson, R.N.,* on the influence of various states of the atmosphere upon Hertzian wave telegraphy. These experiments were all made between ships of the British Royal Navy, furnished with Hertzian wave telegraphy apparatus on the Marconi system. Some of his observations concerned the effect of the interposition of land between two ships. He found that the interposition of land containing iron ores reduced the signaling distances, compared with the maximum distance at open sea, to about 30 per cent. of the latter; whilst hard limestone reduced it to nearly 60 per cent. and soft sandstone or shale to 70 per cent. These results show that there is a considerable absorption effect when waves of certain wave-length pass through or over hard rocks containing iron ores. It would be interesting to know, however, whether this reduction was in any degree proportional to the dryness or moisture of the soil. Earth conductivity is far more dependent upon the presence or absence of moisture than upon the particular nature of the material which composes it other than water.

The observations of Captain Jackson, however, only confirm the already well-known fact that Hertzian waves, as employed in the Marconi system of wireless telegraphy, within a certain range of wave-length, are considerably weakened by their passage through land, over land or round land. In some cases he noticed that quite sharp electric shadows were produced by rocky promontories projecting into the line of transmission. His attention was also directed (*loc. cit.*) to the more important matter of the effect of atmospheric electrical conditions upon the transmission. The effect of all lightning discharges, whether visible or invisible, is to make a record on the telegraphic receiver. On the approach of an atmospheric electrical disturbance towards the receiving station on a ship, the first visible indications generally are the recording of dots at intervals from a few minutes to a few seconds on the telegraphic tape. Captain Jackson states that the most frequent record is that of three dots, the first being separated from the other two by a slight interval like the letters E I on the Morse code, and this is the sign most frequently recorded by distant lightning. But in addition to this, dashes are recorded and

* See *Proc. Roy. Soc.*, May 15, 1902. 'On Some Phenomena affecting the Transmission of Electric Waves over the Surface of the Sea and Earth,' by Capt. H. B. Jackson, R.N., F.R.S.

irregular signs, which, however, sometimes spell out words in the Morse code. He noted that these disturbances are more frequent in summer and autumn than in winter and spring, and in the neighborhood of high mountains more than in the open sea. In settled weather, if present, they reach their maximum between 8 and 10 P. M., and frequently last during the whole of the night, with a minimum of disturbance between 9 A. M. and 1 P. M. Another important matter noted by Captain Jackson is the shorter distance at which signals can usually be received when any electrical disturbances are present in the atmosphere, compared with the distance at which they can be received when none are present. This reduction in signaling distance may vary from 20 to 70 per cent. of that obtainable in fine weather. It does not in any way decrease with the number of lightning flashes, but rather the reverse, the loss in signaling distance generally preceding the first indications on the instrument of the approaching electrical disturbance. It is clear that these observations fit in very well with the theory outlined above, viz., that the atmosphere when impregnated with free electrons or negatively charged gaseous ions is more opaque to Hertzian waves than when they are absent. Captain Jackson gives an instance of ships whose normal signaling distance was 65 miles, failing to communicate at 22 miles when in the neighborhood of a region of electrical disturbance. These effects in the case of wireless telegraphy have their parallel in the disturbances caused to telegraphy with wires by earth currents and magnetic storms.

Another effect which he states reduces the usual maximum signaling distance is the presence of material particles held in suspension by the water spherules in moist atmosphere. The effect has been noticed in the Mediterranean Sea when the sirocco wind is blowing. This is a moist wind conveying dust and salt particles from the African coast. A considerable reduction in signaling distance is produced by its advent.

Another interesting observation due to Captain Jackson is the existence of certain zones of weak signals. Thus, for instance, two ships at a certain distance may be communicating well; if their distance increases, the signaling falls off, but is improved again at a still greater distance. He advances an ingenious theory to show that this fact may be due to the interference between two sets of waves sent out by the transmitter having different wave lengths.

Finally, in the paper referred to, he emphasizes the well-known fact that long distance signaling can only be accomplished by the aid of an aerial wire and a 'good earth.' Summing up his results, he concludes: (1) That intervening land of any kind reduces the practical signaling distance between two ships or stations, compared with that

which would be obtainable over the open sea, and that this loss in distance varies with the height, thickness, contour and nature of the land; (2) material particles, such as dust and salt, held in suspension in a moist atmosphere also reduce the signaling distance, probably by dissipating and absorbing the waves; (3) that electrical disturbances in the atmosphere also act most adversely in addition to affecting the receiving instrument and making false signals or *strays,* as they are called; (4) that with certain forms of transmitting arrangement, interference effects may take place which have the result of creating certain areas of silence very similar to those which are observed in connection with sound signals from a siren.

It is clear, therefore, from all the above observations, that Hertzian wave telegraphy taking place through the terrestrial atmosphere is not by any means equivalent to the propagation of a wave in free or empty space; and that just as the atmosphere varies in its opacity to rays of light, sometimes being clear and sometimes clouded, so it varies from time to time in transparency to Hertzian waves. The cause of this variation in transparency probably being the presence in the atmosphere of negatively charged corpuscles or electrons. If there are present in the atmosphere at certain times 'clouds of electrons' or 'electronic fogs,' these may have the effect of producing a certain opacity, or rather diminution in transparency to Hertzian waves, just as water particles do in the case of sunlight.

We may therefore in conclusion review a few of the outstanding problems awaiting solution in connection with Hertzian wave wireless telegraphy. In spite of the fact that this new telegraphy has not been accorded a very hearty welcome by the representatives of official or established telegraphy in Great Britain, it has reached a point, unquestionably owing to Mr. Marconi's energy and inventive power, at which it is bound to continue its progress. But that progress will not be assisted by shutting our eyes to facts. Many problems of great importance remain to be solved. We have not yet reached a complete solution of all the difficulties connected with isolation of stations. In the next place, the question of localizing the source of the signals and waves is most important. Our kumascopes and receiving appliances at present are like the rudimentary eyes of the lower organisms, which are probably sensitive to mere differences in light and darkness, but which are not able to *see* or *visualize,* in the sense of locating the direction and distance of a radiating or luminous body. Just as we have, as little children, to learn to see, so a similar process has to be accomplished in connection with Hertzian telegraphy, and the accomplishment of this does not seem by any means impossible or even distant. We are dealing with hemispherical waves of electric

and magnetic force, which are sent out from a certain radiating center, and in order to localize that center we have to determine the position of the plane of the wave and also the curvature of the surface at the receiving point. Something therefore equivalent to a range-finder in connection with light is necessary to enable us to locate the distance and the direction of the radiant point.

Lastly, there are important improvements possible in connection with the generation of the waves themselves. At the present moment, our mode of generating Hertzian waves involves a dissipation of energy in the form of the light and heat of the spark. Just as in the case of ordinary artificial illuminants, such as lamps of various kinds, we have to manufacture a large amount of ether radiation of long wave length, which is of no use to us for visual purposes; in fact, creating ninety-five per cent. of dark and useless waves for every five per cent. of luminous or useful waves, so in connection with present methods of generating Hertzian waves, we are bound to manufacture by the discharge spark a large amount of light and heat rays which are not wanted, in order to create the Hertzian waves we desire. It is impossible yet to state precisely what is the efficiency, in the ordinary sense of the word, of a Hertzian wave radiator. How much of the energy imparted to the aerial falls back upon it and contributes to the production of the spark, and how much is discharged into the ether in the form of a wave.

Nothing is more remarkable, however, than the small amount of energy which, if properly utilized in electric wave making, will suffice to influence a sensitive receiver at a distance of even one or two hundred miles. Suppose, for instance, that we charge a condenser consisting of a battery of Leyden jars, having a capacity of one seventy-fifth of a microfarad, to a potential of 15,000 volts; the energy stored up in this condenser is then equal to 1.5 joules, or a little more than one foot-pound. If this energy is discharged in the form of a spark five millimeters in length through the primary coil of an oscillation transformer, associated with an aerial 150 feet in height, the circuits being properly tuned by Mr. Marconi's method, then such an aerial will affect, as he has shown, one of Mr. Marconi's receivers, including a nickel silver filings coherer tube, at a distance of over two hundred miles over sea. Consider what this means. The energy stored up in the Leyden jars cannot all be radiated as wave energy by the aerial, probably only half of it is thus radiated. Hence the impartation to the ether at any one locality of about half a foot-pound of energy in the form of a long Hertzian wave is sufficient to affect sensitive receivers situated at any point on the circumference of a circle of 200 miles radius described on the open sea. Hertzian wave telegraphy is

sometimes described as being extravagant in power, but, as a matter of fact, the most remarkable thing about it is the small amount of power really involved in conducting it. On the other hand, Hertzian wave manufacture is not altogether a matter of power. It is much more dependent upon the manner in which the ether is struck. Just as half an ounce of dynamite in exploding may make more noise than a ton of gunpowder, because it hits the air more suddenly, so the formation of an effective wave in the ether is better achieved by the right application of a small energy than by the wrong mode of application of a much larger amount. If we translate this fact into the language of electronic theory, it amounts simply to this. It is the electron alone which has a grip of the ether. To create an ether wave, we have to start or stop crowds of electrons very suddenly. If in motion, their motion implies energy, but it is not only their energy which is concerned in the wave-making, but the acceleration, positive or negative, *i. e.*, the quickness with which they are started or stopped. It is possible we may discover in time a way of manufacturing long ether waves without the use of an electric spark, but at present we know only one way of doing this, viz., by the discharge of a condenser, and in the discharge of large condensers of very high potentials it is difficult to secure that extreme suddenness of starting the discharge which we can do in the case of smaller capacities and voltages.

How strange it is that the discharge of a Leyden jar studied so profoundly by Franklin, Henry, Faraday, Maxwell, Kelvin and Lodge should have become an electrical engineering appliance of great importance!

Whilst there are many matters connected with the commercial aspect of Hertzian wave telegraphy with which we are not here concerned, there is one on which a word may properly be said. The ability to communicate over long distances by Hertzian waves is now demonstrated beyond question, and even if all difficulties are not overcome at once, it has a field of very practical utility, and may even become of national importance. Under these circumstances, we may consider whether it is absolutely necessary to place the signaling stations so near the coast. The greater facility of transmission over sea has already been discussed and explained, but in time of war, the masts and towers which are essential at present in connection with transmitting stations could be wrecked by shot or shell from an enemy's battleship at a distance of five or six miles out at sea, and would certainly be done within territorial waters. Should not this question receive attention in choosing the location of important signaling stations? For if they can, without prejudice to their use, be placed inland by a distance sufficient to conceal them from sight, their value as a national asset in time of war might be greatly increased.

It has been often contended that whilst cables could be cut in time of war no one can cut the ether; but wireless telegraph stations in exposed situations on high promontories, where they are visible for ten to fifteen miles out at sea and undefended by any forts, could easily be destroyed. The great towers which are essential to carry large aerials are a conspicuous object for ten miles out at sea; and a single well-placed shell from a six-inch gun would wreck the place and put the station completely out of use for many months. Hence if oceanic telegraphy is ever to be conducted in a manner in which the communication will be inviolable or, at any rate, not be capable of interruption by acts of war, the careful selection of the sites for stations is a matter of importance. A small station consisting of a single 150-foot mast and a wooden hut can easily be removed or replaced, but an expensive power station, the mere aerial of which may cost several thousand pounds, is not to be put up in a short time.*

Meanwhile, whatever may be the future achievements of this new *supermarine* wireless telegraphy conducted over long distances, there can be no question as to its enormous utility and present value for intercommunication between ships on the ocean and ships and the shore. At the present time, there are some forty or more of the transatlantic ocean liners and many other ships equipped with this Hertzian wave wireless telegraph apparatus on the Marconi system. Provided with this latest weapon of applied science, they are able to chat with one another, though a hundred miles apart on the ocean, with the ease of guests round a dinner table, to exchange news or make demands for assistance.

> **Ships that pass in the night, and speak each other in passing—**
> **Only a signal shown, and a distant voice in the darkness;**
> **So, on the ocean of life, we pass and speak one another,**
> **Only a look and a voice, then darkness again, and a silence.**

Abundant experience has been gathered to show the inexpressible value of this means of communication in case of accident, and it can hardly be doubted that before long the possession of this apparatus on board every passenger vessel will be demanded by the public, even if not made compulsory. Although the privacy of an ocean voyage may have been somewhat diminished by this utilization of ether waves, there is a vast compensation in the security that is thereby gained to human life and property by this latest application of the great energies of nature for the use and benefit of mankind.

*** Mr. Marconi has informed the writer that these strategic questions have received attention in selecting the sites for large Marconi power stations in Italy.**

THE SALMON AND SALMON STREAMS OF ALASKA.

By President DAVID STARR JORDAN,
LELAND STANFORD JUNIOR UNIVERSITY.

The Salmon of the Pacific.

THE salmon of the Pacific differ notably as a whole from the single species called salmon (*Salmo salar*) in the Atlantic. Anatomically the Pacific salmon (*Oncorhynchus*) differ from the salmon of the Atlantic (*Salmo*) in the greater number (14 to 20) of developed anal rays (the Atlantic salmon having 10 to 12), in the greater number of branchiostegal rays, 13 to 16, the Atlantic salmon having about 11, and in the usually larger number of pyloric cæca, 65 to 180, the Atlantic salmon having 65. In habits, the distinctions are still more marked. The Atlantic salmon spawns in the small streams and runs in the rivers in the fall for a long distance. In the run, the males become hook-jawed and somewhat distorted and many are attacked by fungus, dying before reaching the sea. But they attempt to reach the sea, and a large percentage of them revive, to spawn again.

The Pacific salmon, *Oncorhynchus,* have more definite runs. In the process of running, they take no food of any kind. The oil in the body is consumed, the flesh becomes pale, the jaws in the males become much elongated, the front teeth are enlarged, the color is changed and the whole body is greatly distorted. After spawning the fishes drift tail foremost in the stream, and all die within about a week. There is no reason to believe that any individuals of any species of Pacific salmon survive the reproductive act.

All the salmon spawn in cold or cooling water. The eggs are hatched when the water cools to 54°. Freezing kills them but any temperature between 32° and 54° is favorable to their development. Any temperature above 54° causes the egg to develop precociously and the young salmon dies. The temperature of the streams of the north fall earliest to 54°. For this reason, the run is earlier in northern waters than in southern ones in Alaska. All the species spawn in flowing water, the male with its tail scooping out the gravel in which the female deposits the eggs and over which the male casts out the milt.

The Species of Pacific Salmon.

There are five species of salmon in Alaska and neighboring regions. These differ widely in habit and in value, a matter of vital importance to an understanding of the salmon question.

The Quinnat Salmon.

1. The Quinnat salmon (*Oncorhynchus tschawytscha* Walbaum). This species is called king salmon in Alaska, Chinook salmon on the Columbia, spring salmon on Fraser River, Tyee salmon where the Chinook jargon is spoken and Tchaviche among the Russians. This is the salmon of the Columbia and Sacramento, the only species having value south of Puget Sound. It reaches a larger size than any of the others, the average at four years being 22 pounds and occasionally running to 60, 80 or even 100 pounds. In quality of flesh it is also superior to any of the others, at its best no wise inferior to the Atlantic salmon. Its flesh is red, rich and tender, becoming however progressively paler in color and less rich in flavor, as the spawning season approaches, although the flesh of spawning fish is sometimes dull red. The Quinnat is readily known by its large size and the presence of round black spots on back and tail. As the breeding season approaches it becomes blackish, the sides blotched with dull red.

The Quinnat runs in the large rivers, especially those having glacial or snow-fed tributaries. Its chief run is in May in the north, in June and sometimes in early July in the Columbia and even later in the Sacramento. In the Columbia, there is a more or less distinct full run in September. In Alaska, the principal run is in May.

The Quinnat salmon runs to the very headwaters of the streams it inhabits. In the Columbia, it goes to the Sawtooth Mountains of Idaho, as well as to the headwaters of the Clackamas, Cowlitz, Des Chûtes and other streams furnishing suitable spawning beds. In the Yukon some individuals each year ascend to Caribou Crossing on Lake Bennett, a distance of 2,250 miles from the sea. In Alaska the king salmon runs in appreciable numbers in the following rivers: Stikine, Taku, Unuk, Chilkat, Alsek, Kussilof, Copper, Knik, Shushitna, Nushigak and Kvichak. Schools of king salmon are occasionally seen among the islands of southeast Alaska, in pursuit of schools of herring. It is not likely that the species goes far out to sea, or for any great distance from the stream in which it was spawned. It is commonly asserted that each salmon returns to the particular stream in which it was spawned. There is no evidence that this is true. A discussion of this point will be found in a previous article in this journal.

The Red Salmon.

The red salmon (*Oncorhynchus nerka* Walbaum). This fish is known throughout Alaska as red salmon. In the Columbia, it is called blue-back salmon, while in Fraser River it is known as Sockeye, a Chinook word, originally spelled Sukkegh, then Sawkwi. To the

Russians it is Krasnaya Ryba, which means red-fish. This species is the neatest and most symmetrical of the salmon. Its usual weight at four years is about seven pounds, varying from six to ten pounds. The flesh is deep-red, firmer, drier and less palatable than that of the Quinnat. The flesh is more compact than that of any other salmon, hence in canning it is boiled longer. In the sea the red salmon is clear sky-blue above, silvery below, without spots. After entering the river, for the purpose of spawning, the color soon changes to crimson, at first bright, but soon blotched with darker and blood-red, the head becoming bright olive green in sharp contrast with the red. The jaws in the male become extravagantly produced and hooked.

This species runs chiefly in July, and often goes for a very long distance. In the Yukon, it ascends to 'Forty Mile,' a distance of over 1,800 miles from the sea. In the Columbia, it ranges as far as the lakes of the Sawtooth range in Idaho. It always spawns in small streams which run into the head of a lake. It never runs in any stream which does not have as a tributary a lake with available spawning grounds in the streams at its head. The red salmon often enters small streams, even those a few feet across, and sometimes in great numbers. The determining factor is always the presence of a suitable lake with spawning beds above it. The lake may be a few rods from the sea as at Boca de Quadra, or it may be many hundreds of miles as in the case of the Columbia, but the lake is always present in every stream in which red salmon run.

In certain large lakes at a distance from the sea, in Idaho, there is a dwarf form of the red salmon, exactly similar to the sea form, but rarely exceeding half a pound in weight. These are probably land-locked in these lakes as both sexes are freely represented among them. At the sea, the dwarf fish running are almost all males. In the spawning season of the Quinnat salmon, many young males but one or two years of age enter the river with the larger fish, spawning precociously, and all dying. Perhaps these dwarf red salmon are simply precocious individuals spawning and dying before their time. No females were seen among these by us at Astoria. In streams of Cook Inlet, there is a late run of very small red salmon, locally known as 'Arctic salmon.' These are doubtless young fish running prematurely. They are not confined to Cook Inlet, but many were seen by us at Karluk. Of a large number examined, all but two were found to be males. The small red-fish running in Necker Bay on Baranof Island are of the same nature. With them are some full grown red salmon. Why this particular stream is attractive to precociously spawning fish is a matter for investigation.

The Silver Salmon.

The silver salmon (*Oncorhynchus milktschitsch*) is called Coho about Puget Sound, Kisutch or Bielaya Ryba (white-fish) by the Russians. This species is very similar in size and color to the red salmon. It is distinguished at once by the much smaller number of gill-rakers (23 instead of 37). Its dorsal fin is always black at tip. The flesh is less firm than that of the red salmon, and the scales fall off when the fish is handled, leaving only those along the lateral line. The fine texture and loose attachment of the scales is the most convenient mark to distinguish the silver salmon. In the spawning season it becomes hook-nosed and the color changes to blotchy red. The flesh of the silver salmon is rather pale, without the deep red hue of the red salmon. In flavor it is rather better than the latter, and only the pale color keeps it from ranking with the best of salmon.

The silver salmon runs in the fall and ascends the streams for a short distance only. It remains close in shore. The young can be taken with a seine at almost any time along the shores in Alaska, and these seem to remain in the rivers longer than the young of the other species. The species is taken in small numbers at all the fishing grounds in Alaska. When enough are taken, it is canned as 'Coho' or as 'medium red,' but no dependence can be placed on it. It runs in Alaska from August 15 to September 15. When it begins to run in the streams it is not far from its spawning time, and its flesh is deteriorated. For these reasons, although a fine food-fish, it will never have much economic importance.

The silver salmon is common in the rivers of Japan. The king salmon is unknown in Japan, there being no ice-fed rivers suitable for it. The red salmon runs in a few lakes (as Lake Akan) in the extreme north (Nemuro) of the northern island of Hokkaido or Yeso.

The Humpback Salmon.

The humpback salmon (*Oncorhynchus gorbuscha*) is known to the Russians as Gorbuscha and to the trade as pink salmon. This is a small fish, seldom weighing over six pounds and often not over three. It differs from the other salmon in its very small scales. The presence of oblong black spots on the tail is also characteristic. Its flesh is soft, very much less firm than in the preceding species. It is pale in color, and without much of the characteristic salmon flavor. When fresh it is fairly palatable and quite wholesome, and the bellies when salted are of good quality. The flesh becomes soft in a short time after death, becoming tainted in 48 hours or less in the cool climate of Alaska. When the species begins to run in the river, its flesh loses the little oil it has and is almost worthless as food. The humpback salmon

carries the changes due to the spawning period to an extravagant degree, being hook-jawed, hump-shouldered and distorted more excessively than any other species.

The humpback is the most abundant of the salmon among the Alaskan Islands. It exists in millions, it swarms everywhere in waters near the sea, breeding in brooks, lakes, swamps and brackish estuaries—anywhere where a little fresh water can be found. It runs for a slight distance, and does not go far from the shore. From its great abundance and the ease by which it is taken in nets, this species is exceedingly cheap in Alaska, the individuals costing about a cent apiece. In the large rivers, the humpback rarely runs. It is therefore almost unknown in the Sacramento, the Columbia and even the Fraser River. Small rivers which do not rise in lakes are often crowded with humpbacks. Such streams are known as humpback streams.

The humpback is not found in Japan, where it is replaced by a closely allied species, with unspotted tail, the Masu (*Oncorhynchus masou*).

The Dog Salmon.

The dog salmon (*Oncorhynchus keta*) is known also as calico salmon and as chum, to the Russians as Hayko, and in Japan where it is especially abundant as Saké. It is rather larger than the silver salmon, averaging about ten pounds. It is plump and silvery, when taken in the sea, and may then be best distinguished from the red salmon by the tendency of the dark color of the back to form vertical bars on the side. In the breeding season, it becomes largely black, still obscurely barred, and the jaws are greatly elongated and distorted.

The flesh of the dog salmon is very pale, with little of the salmon flavor and none of its color. When fresh from the sea it is however well-flavored and wholesome. When canned it is dirty white, soft and mushy, and with a strong taste of mud. It is then practically worthless as food. It runs in the rivers in the fall and for very short distances. Its flesh is then still more pale and mushy. It is in fact unfit for canning, and the few firms who have packed it have been unable to dispose of the goods. The 'Rainbow Brand' was established for dog salmon.

The dog salmon takes salt well. It is the large salmon or saki of Japan, of which great quantities are salted in Japan, and Japan has also furnished a market for the same species salted in Alaska. The dog salmon—taken fresh in spring—is frozen and sent in cold storage to the East and to Germany, where it sells readily. The species is attractive in appearance, and when taken in the sea is good food, although unsuited for canning purposes.

The dog salmon enters all sorts of rivers in the fall, spawning at no great distance from the sea. It is less abundant than any of the other species, although it can be taken in almost any stream from the Columbia River to the rivers of northern Japan.

The relative food value of the five different species of salmon may be well expressed by the five digits, Quinnat five, red salmon four, silver salmon three, humpback salmon two, dog salmon one. The canned product has at the present time approximately the same relation of values, except that the aggregate value of the red salmon now considerably exceeds that of the Quinnat.

The Trout of Alaska.

Besides the five species of salmon, four species of trout are found in Alaska. These may be briefly noticed. The steel head trout (*Salmo gairdneri*) is frequently taken in the mouths of the large streams, which it enters for the purpose of spawning. It reaches a weight of 10 to 16 pounds. The large examples are valued for purposes of cold storage. The species is sometimes salted, but rarely canned. It is a handsome fish, black spotted, and may be known by the very short head, which it one fifth the whole length to the base of the tail.

The cut-throat trout (*Salmo clarki*) is found in streams about Sitka and southward to Vancouver Island. It has no economic value in Alaska. Although sometimes weighing 15 to 25 pounds in favorable lakes, it does not ordinarily exceed three pounds. The species may always be known by a concealed dash of scarlet on each side of the throat. This is wanting in the steel-head, which is likewise spotted with black.

The rainbow trout (*Salmo irideus*) occurs also in Alaska. It has been taken in Naha River at Loring and in some other places. It lacks the red dash of the cut-throat trout and has larger scales. From the steel-head it is separated by its larger head, larger scales and smaller size.

The Dolly Varden (*Salvelinus malma*), miscalled 'salmon trout' in Alaska, is one of the most abundant fishes in Alaska. It swarms in every stream and enters the sea, where it occasionally reaches the weight of eleven pounds. The young trout are the most persistent enemies of the salmon fry, destroying them by millions, although in turn the salmon feed on the fry of the trout. The Dolly Varden is one of the finest game fish—a fact little appreciated in Alaska. In the rivers, its color is rich dark blue or olive with crimson spots. In the sea, this color changes to steel gray with spots of paler gray.

The trout is an excellent food fish, but of no economic value except about the towns where it may be consumed fresh. It can not be taken

in such numbers as the interests of canning require, and it is too small for advantageous sale in cold storage. The Dolly Varden is wholly wanting in the Upper Yukon region.

The Great Lake trout or Mackinaw trout (*Cristivomer namaycush*) is common in the Yukon region, which has a fauna very much like that of Lake Superior. It abounds in the lakes, takes a hook readily and reaches a weight of 50 pounds or more. A certain number of these are shipped fresh to mining centers, as White Horse and Dawson.

The Streams of Alaska.

The rivers of Alaska, considered in relation to the salmon industry, may be divided into three classes. King salmon streams, red salmon streams and humpback salmon streams. The streams of the first class from a quarter of a mile to a hundred miles wide at the mouth, have a long course and are fed by melting ice or snow, and the course for the most part is not through glacial lakes. In these rivers the king salmon or Quinnat salmon run in the spring, as in the Sacramento or Columbia. With them run also a certain number of red salmon, and in the river mouths humpback, dog and silver salmon. The run of the king salmon is however the chief characteristic. The species in Alaska is less valuable than in the Columbia, because owing to the shorter run the fishes are nearer the spawning season and a large percentage have white meat even in June, a larger percentage than the Columbia shows even in August. For various reasons, rough bottom, swift current, high tides, etc., most of these streams are not easily fished. In the Stikine River, for example, traps are swept away by the currents, seines are tangled up, a deep gill net will meet an under current of salt water under the fresh water, and is thus upset. The only effective fishing gear is therefore a very shallow gill net floating in the fresh water at the surface. Rivers of the first class are the following: Yukon, Kuskoquim, Shushitna, Copper, Alsek, Taku, Speel, Whiting, Stikine and Unuk Rivers. The streams about Bristol Bay should not be placed in this class, as they flow through lakes and are essentially red salmon streams, in spite of their large size.

The streams of the second class or red salmon streams are those of large or small size which flow through lakes or have lakes tributary to them. In all these the red salmon runs freely, spawning always in the gravelly bed of the stream at the head of some lake. The four greatest of red salmon streams are the Fraser River, Karluk River, Nushegak River and Kvichak River, all large streams flowing through lakes. In proportion to the amount of water, probably no stream in the world normally carries more salmon than the Karluk River.

The streams of the third class, or humpback salmon streams, comprise the remaining streams of Alaska. These may be large swift

rivers as the Skaguay River, or they may be little brooks, in any case not frequented by the king salmon, and having no lake in the course, hence not fit for the red salmon. Their runs are confined to the ignoble species, which ascend for a short distance only. In the larger streams to the northward as Skaguay River and Dyea River, the dog salmon predominates. Southward as in Fish Creek, at Ketchikan and Anan Creek, the humpback salmon predominates, although the humpback is equally common in the red salmon streams. Some of these streams of the third class as Fish Creek flow through lakes. Presumably these lack fit spawning grounds.

The question as to what constitutes the mouth of the river is one of some importance in Alaska. The tides run very high, often twenty-five feet or more, the high tide extending far up the estuaries, which at low tide may be occupied by fresh water. The Naha Stream at Loring flows through a series of lakes, the lowermost of which (Roosevelt Lagoon) lies close to the estuary of the stream, the water flowing from the lake over a considerable waterfall at low water. At high tide this cascade is reversed, the salt water passes by an overfall into the lake, which is thus converted into a brackish lagoon. It is a well separated lake at low water, part of the sea at high water.

THE STORM CENTER IN THE BALKANS.

By Dr. ALLAN McLAUGHLIN,
U. S. PUBLIC HEALTH AND MARINE HOSPITAL SERVICE.

MANY students of European political conditions believe that the end of Turkey as a European power is in sight and that in the near future important events will occur in the Balkan Peninsula which will change the map of that part of Europe.

The solution of the Balkan question has been confidently expected at various times during the past fifty years, but never have the signs of the times so consistently pointed toward this result as they do at the present time. The condition of anarchy and guerilla warfare in the so-called province of Macedonia and the accounts of wholesale murder of old men, women and children, even after due allowance for possible exaggeration, must excite a feeling of horror in the most indifferent observer. The position of the christian inhabitants in the unhappy country is such as to cause an outburst of popular feeling even in England against the Turk. The significance of the tone of hostility evinced by the English press lies in the fact that hitherto England has been the chief supporter of the Turk's political position in Europe.

The polyglot population of these Turkish provinces, differing from the Turk no less than from one another in race and speech, makes a favorable soil for the sowing of seeds of political discord, the value of which outside influences are not slow to recognize.

The Turk has availed himself of the racial differences of his subjects and encouraged the hostility of Greek for Slav, and the hatred of the Albanian for both. To understand the complicated conditions of the present insurrection it is necessary to consider the racial factors which go to form the population of the disaffected provinces and to review briefly the outside influences which tend to keep the Balkan question alive, and the reasons why the question has not sooner been settled.

There is no official division of the Turkish empire known as Macedonia; but the name has a wide popular usage in designating the territory occupied by these warring racial elements of European Turkey. The name is popularly applied to the Turkish vilayets of Salonika and Monastir. The resident factors in the racial problem of Macedonia consist of Slavs (Bulgars and Serbs), Albanians, Greeks, Roumans and Turks.

The Slavs came into Macedonia in the seventh century. They came in irresistible numbers, forced the Albanians to the mountains

of the west, the Greeks to the south and the Roumans to the north. Two distinct elements were concerned in the Slavic invasion, the Bulgars and Serbs. The Bulgar and Serb alternated in the supremacy of the country for nearly eight centuries, until the Turk finally conquered both. For the past four hundred years the sultan has ruled the country and his rule has been frequently marked by barbaric cruelty and fanatical race hatred. The Slavic race (Servian or Bulgarian) predominates numerically in Macedonia. The race types that have survived the Slavic invasion and the Turkish conquest (Rouman, Greek and Albanian) are all modified by the infusion of Slavic blood.

Greeks are scattered throughout Macedonia in considerable numbers. They are mostly in the cities and towns engaged in trade and commerce, and are like the Rouman—inclined to let the Slav till the soil. The feeling between Greek and Turk is what might be expected after the race conflict of centuries. The Greek can never consider the Turk as anything but an intruder, and he will never relinquish his cherished dream of a great Greek empire with Constantinople for its capital. Yet many Greeks see their way clear to accept Turkish pay and assist in defeating the revolutionary schemes of their Slavic neighbors, the Bulgars.

The Wallachs, Vlachs or Roumans are a distinct division of the Latin family of peoples and to-day number about 5,000,000, most of them in Roumania; but Roumans are found in Bessarabia, Transylvania, Hungary, Albania and Macedonia. In Macedonia are numerous colonies of Roumans; and the Zintzars, as these Macedo-Roumans are called, are a factor of considerable importance in the question of the future of Macedonia. They are descended from a blended stock made up of Roman colonists and disbanded soldiers, and the Illyrian and Thracian inhabitants of Macedonia at the time of the Roman conquest (146 B. C.). The whole of Macedonia was, up to the seventh century and the coming of the Slav, occupied by a Latin-speaking race. The Slavic conquest forced the Roumans in great numbers to their brothers north of the Danube and many were carried farther by the wave of invasion—as far west as the Tyrol. The supremacy of the Slav did not wipe out the Rouman race, although the races probably blended to some extent. The Rouman exists to-day as a distinct type, speaking a Romance language and possessing in a marked degree the pride of race common to all peoples of Roman blood. In physical appearance the Vlachs are short and dark. They are very industrious and are usually engaged in trade and manufacturing. They are skilled in the building trades and metal working.

The Albanians are probably the chief disturbing element in Macedonia to-day, if we except outside influences. They constitute an important factor in the question, not only because thousands of them live in western Macedonia, but because many thousands more

are enrolled in the Turkish army as irregular troops, or bashi-bazouks. The cradle of their race lies along the shores of the Adriatic from Montenegro on the north to Greece on the south. The country corresponds to ancient Epirus and in physical character resembles the highlands of Scotland. They are descended from the old Illyrians, who were never recognized as Hellenes by the ancient Greeks, but were probably allied to the Greeks racially.

The Roman occupation left many traces, especially in the valleys and more accessible parts of the country, and the great number of Latin derivatives in the Albanian language makes it semi-Romance in character as spoken to-day. The Albanians have blended to some extent also with Slavic elements in the north and Greeks in the south. Their religion is a form of Mohammedanism, but they take their religion less seriously than the moslem Turk and probably embraced it more for political reasons than for feelings of religious conviction. They made a magnificent fight against the conquering Turks in the fifteenth century. For twenty years under their heroic leader, George Castriot, they repelled army after army sent against them. After the death of Castriot, or Scanderbeg, as the Turks called him, the Albanians lost heart and with the fall of Scutari in 1478 they passed under Turkish dominion. They were governed by pashas appointed by the Porte, and under one of these, Ali Pasha, in the early part of the last century they became practically independent. They at first sympathized with Greece in the Grecian war for independence, but the Greeks refused their offers of friendship, and in a certain town besieged and captured by Greeks, there were massacred along with the Turkish garrison a body of 3,000 Albanians who had signified their willingness to desert the Turks and deliver the town to the Greek besiegers. Their treatment at the hands of the Greeks forced the Albanians into the arms of the Turk, and they have since fought valiantly to maintain the supremacy of the Porte. Their native dress is not unlike that of the Scotch highlander, and their skill and bravery in war, their constant interclan strife and their fierce untamable character make the analogy almost complete between the Scotch highlander and this other highlander of the Albanian mountains. The Albanian is a born plunderer. War is his business, and pillage his pastime; and he is held in great dread by the Slav, Rouman and Greek inhabitants of Macedonia.

The Macedonian question is kept alive by several distinct forces. The warring racial elements—Slav, Greek, Rouman and Albanian—and common hatred of the christian inhabitants for the Turk cause constant turmoil and riot. The desire of Servia, Bulgaria and Greece to annex Macedonia no doubt also contributes to the local unrest. The influence of Russia must not be overlooked. Russia has been accused, and history supports the accusation, of fomenting insurrection in

Macedonia through the agency of the Macedonian Revolutionary Committee.

Thus in this small territory of Macedonia we have five distinct elements, each discontented with Turkish domination, and yet each suspicious of his neighbor and fellow sufferer of alien race. The Albanian is at present on the side of the Turk. The Greek hates the Albanian, fears the Slav and detests the Rouman; yet hopes to dominate all three in some miraculous way from Constantinople after the Turk is forced out of Europe.

The Rouman hopes for the restoration of Rouman supremacy in the Balkan states through the agency of Roumania. The Serb and Bulgar are suspicious of the Greek and yet do not trust each other. All these races have one thing in common—the desire to free themselves from Turkey. The sultan is clever enough to take advantage of these race quarrels in Macedonia. In this game he has played Greek against Slav, and the Albanian against both, and thus made his own supremacy secure.

Russia has continually stirred up trouble in the Balkans, hoping to profit thereby. Each state separated from the Turkish empire brought Russia one step nearer the Bosphorus. In fact, Russia if left to herself would have settled the Macedonian question long ago. But this would necessitate driving the Turk across the Bosphorus and Russian occupation of Constantinople.

With Russia in Constantinople, the control of the eastern end of the Mediterranean sea and the entrance to the Suez canal would be lost to England. The weak Slavic Balkan states would become Russian, and the Slovenes and Croats, and all Austria's Slavic dominion south of the Danube would probably be lost to Russia.

England can never permit Russia to occupy Constantinople and control the great waterway to India, no matter what sentimental reasons might be advanced for ending Turkish barbarity. Austria must consider each Russian advance toward Constantinople as a step toward her own impending disintegration.

Germany, with the kindly feeling engendered by liberal railway concessions in Asia Minor and Mesopotamia, will endeavor to strengthen the sultan's failing grasp on the last European province left him. Time alone can tell what action the great powers will take. Turkey and Bulgaria are on the verge of war and in the event of such a war European intervention would surely follow.

It is almost certain that the powers will intervene anyway and give to the disaffected provinces some form of civilized government. It is very unlikely that Russia will soon occupy Constantinople. All the great powers, with the possible exception of France, would be against such a step. Nor is it likely that the petty ambition of Servia, Bulgaria, Roumania or Greece will be gratified by territorial acquisitions in Macedonia.

THE GROWTH OF RURAL POPULATION.

By FRANK T. CARLTON,
TOLEDO UNIVERSITY SCHOOL.

IN the last decade numerous articles were written and many warnings sounded regarding the depopulation of the rural districts in the eastern and north central portions of the United States. To a person believing that the country, not the city, furnishes the 'bone and sinew' of the nation, a study of the census returns for 1890 provided sufficient foundation for such articles. Now another ten years have passed into history; new and, in many cases, quite different industrial conditions obtain; a new census has been taken and its results are now available. It is the purpose of this article to discuss the tendencies which are found at the present time in regard to the changes in rural population and to show that an improvement in rural conditions seems to be indicated by statistical study as well as by a survey of the social and industrial situation.

Taking the township as a basis of comparison, we find that during the decade, 1880–1890, the population decreased in 57 per cent. of the townships of the state of Ohio, in 48 per cent. of those of Indiana and in 56 per cent. of the townships of Illinois; during the decade, 1890–1900, the percentages are, respectively, 52, 43½ and 34. In these three north central states a total of 2,037 townships, or 54½ per cent., decreased in population during 1880–1890; but only 1,631, or 43 per

State.	Number of cities having a population of 25,000 or more.	Total increase in population of these cities, 1880–1890.	Same, 1890–1900.	Total increase in population of state, 1880–1890.	Same, 1890–1900.	Total increase in population of state outside large cities, 1880–1890.	Same, 1890–1900.
New York.....	12	848,481	1,052,155	914,982	1,265,251	66,501	213,096
Ohio.....	9	287,188	298,958	474,254	485,229	187,066	186,271
Indiana.....	5	72,683	103,337	214,103	324,058	141,420	220 721
Illinois.....	7	646,122	655,797	748,480	995,199	102,358	339,402
Massachusetts..	19	305,409	366,160	455,858	566,403	150,449	200,243
Vermont.....	none			136	11,219	136	11,219
New Hampshire.	1	11,496	12,861	29,539	35,058	18,043	22,197
New Jersey.....	10	205,053	238,268	313,817	438,736	108,764	200,468
Delaware.....	1	18,953	16,077	21,885	16,242	2,932	1,165
Total.....	64	2,395,385	2,743,613			777,669	1,394,782

cent., decreased during the last decade. New York shows little change, the figures for the two decades being nearly identical. In Massachusetts, only 34 per cent. of the townships show a decrease in population during the last decade.

The above table presents several important and interesting facts regarding distribution of the increase in population of the nine states studied. All except Delaware show a greater increase in the population of the large cities during the period 1890–1900 than during the preceding decade. Delaware and Ohio, outside of the large cities, increased less during 1890–1900 than during 1880–1890. In Delaware alone the entire population of the state increased less during 1890–1900 than during the decade preceding. In these nine representative states, the population of the large cities increased 347,227 more during 1890–1900 than during 1880–1890; while the remaining portion of the states, the rural districts, increased 517,313 more during 1890–1900 than during 1880–1890.

These figures indicate that, although the growth of our large cities is still more rapid than that of the remaining parts of the country, the rural districts are not being depopulated; but, on the contrary, are rapidly increasing in population. The growth is by no means uniform. The counties near the rapidly growing cities of Chicago, Cleveland and Toledo are increasing in population; while many in central and southern Ohio are decreasing. The contrast between New Jersey and Delaware, as shown in the table, is undoubtedly to be attributed to the influence of New York City and Philadelphia in the case of New Jersey, and the lack of such influence in the case of Delaware. The writer attributes much of this growth in the vicinity of these cities to the development of an extensive suburban electric railroad system. This may be objected to on the ground that the electric roads were not in operation long enough before 1900 to produce an appreciable effect. In order to prove or disprove definitely the census of 1910 will be required.

In the state of New Jersey only one county, Huntingdon, decreased in population during the last decade. Of the 104 cities, towns and boroughs in this state separately returned in both 1890 and 1900, 86 increased during that period. Only two counties, Barnstable, in the Cape Cod district, and Nantucket, an island, in the state of Massachusetts, show a decrease in population during the last decade. The three New England states, Maine, New Hampshire and Vermont, report only two cities having a population of more than 25,000 people; they may, therefore, be called 'rural' states. An examination of the population of these three states reveals one significant common tendency—the percentage of increase was greater in each state during 1870–1880 than during 1880–1890; but the percentage for 1890–1900

was greater than for 1870–1880. There is a distinct recovery in the rate of increase in population.

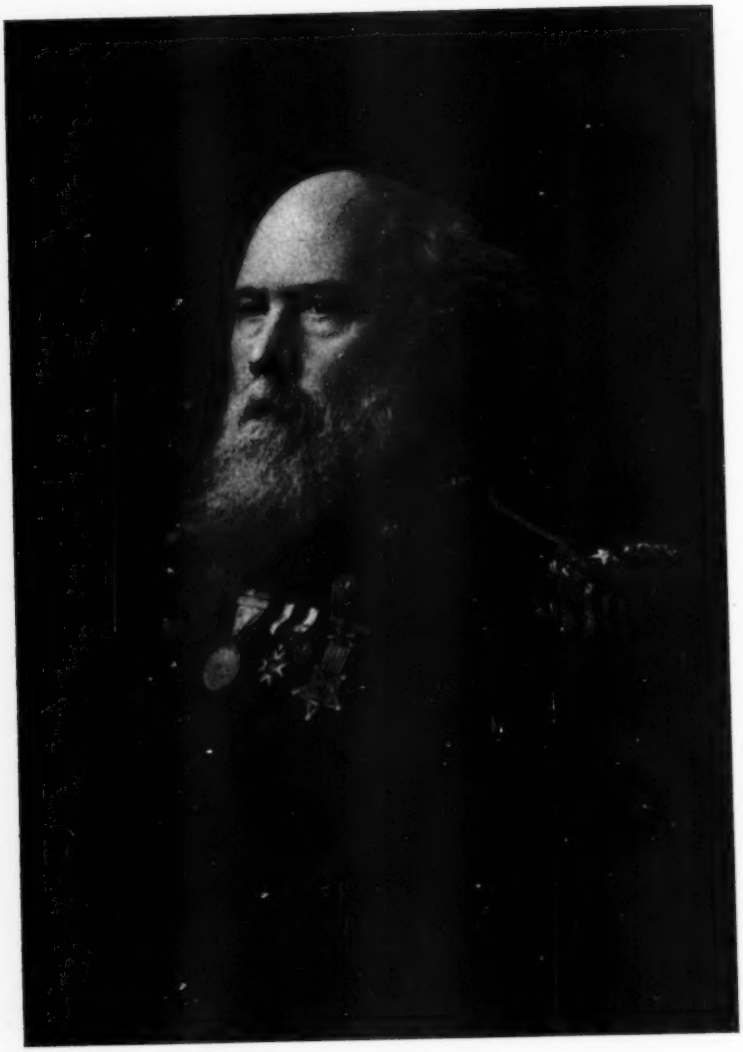
The statistics given of the north central and New England states show that, taken as a whole, the rural sections are not being depopulated, but are increasing in population at a gradually accelerated rate; townships and villages located near large cities, as a rule, show the greatest gain in population; better methods of transportation and communication and improved social conditions actually do tend to stop the depopulation of the rural districts. The reasons which may be given for this increased rate of growth in the population of the rural and suburban districts are many. They may be conveniently classified as follows: First, recent changes and improvements in industrial methods and conditions; second, the improvement in the home and social life of rural communities, due to better methods of transportation and communication.

At present there is a marked tendency for manufacturing plants to locate in the suburbs or the outskirts of a city. It seems probable that this tendency is to continue and that our manufacturing establishments are in the future to be located farther from the crowded portions of a large city or in a small city or town. The value of land is lower and rents are lower than in the densely populated portions of the city. Better shipping facilities can usually be obtained; switches can be built into the plant itself with little expense. The old two-, three-, or more story shop is being supplanted by the one-story steel structure; methods of construction have undergone a radical change in recent years. The new style building is better lighted, heated and ventilated than the old; it also requires more floor space and provides for traveling cranes to carry heavy parts of machinery. Coincident with this change in shop construction has come a change in the methods of transmitting power. Shafting and belting are being replaced in many new shops by compressed air and electricity. The use of compressed air and electricity allows the machines to be spaced much farther apart, as power can be economically transmitted over a much greater distance than in the case where shafts and belts are used. Long distance transmission of electrical power and the utilization of water power will aid in scattering manufacturing establishments in localities outside the large cities—witness the rapid growth of industrial settlements near Niagara Falls and the Sault Sainte Marie. Water power is destined to play a continually increasing part in industrial operations; but if we are able to transmit power economically to considerable distances, there will be no necessity for a close concentration of manufacturing plants in the vicinity of any water-fall. No claim is made that such a change involves a return to smaller units or to a greater number of small proprietors. It, taken in connection with the preceding, does, however,

point to a scattering of manufacturing plants; to a spreading out over more ground space in the case of each individual establishment and to more healthful, natural and inviting home and shop surroundings for the working men. One company may own many plants located on one large site or in many different parts of the United States, as circumstances may dictate. The great economies which consolidation permit are in the expense of management, in buying, selling, advertising and the like. These are as readily obtained when the business is carried on in several moderately large establishments as in one mammoth one. Increased facilities for rapid transportation also allow workmen to live many miles from their work. In this connection one more point must be discussed. Employers as well as students of social conditions are beginning to understand that the efficiency and value of workingmen to their employer depends, in a large measure, upon the home and shop conditions and environment. Poorly fed, poorly housed and poorly clothed workmen are not efficient laborers; also, dark, dingy, unsightly, poorly ventilated and badly heated factories are distinctly detrimental to the amount and quality of the work done in them. Looking at the matter from the standpoint of profits, as purely a business proposition, employers are beginning to realize this fact and to attempt to remedy it. The following quotation, taken from a magazine devoted to shop management and economy, illustrates the trend of thought: "The duty of a corporation, like that of an individual, is of a dual nature, viz., toward itself and toward its neighbors. Its duty to itself comprises the necessity of turning out its product cheaply and at the same time excellent in quality. To fulfill these requirements the management must see that the component factors of production are kept in prime condition. The more intelligent the employees and the more efficient their facilities for production, other things being equal, the cheaper and better will be the resultant output. . . . The manager who lives in luxury, without seeming to care for the condition or welfare of his employees, rouses antagonisms, which are not conducive to collaboration with his interests either in the works or in the community." A better grade of workingmen is, as a rule, attracted to a shop located in the suburbs owing to its superior advantages in regard to shop and home environment. The theory of demand and supply is not the sum and substance of economic thought and reasoning. The human element must be considered. Humanitarian principles are beginning to be recognized in the business world and must be reckoned with in the future.

The improvement of the rural school, the increased rural circulation of the daily paper and the magazine, the electric suburban and interurban railroads, improved roads, rural mail delivery, the extension of the telephone service into the rural districts and many other improve-

ments and innovations which improve the social condition of the country people all tend to increase the wants of the rural communities, to raise their standard of living and hence to increase the real wages of the dwellers in those places. Here stands revealed one of the positive forces which is stopping the drift of population from country to city. The standard of living of the rural population has been lower than that of urban communities. The wants of the farmer have been few and simple; but better facilities for communication, for travel and for intercourse with his fellow men are improving his social and economic condition. Those who have been most ambitious, whose standard of living has been the highest, have been forced, of necessity, to migrate first to the town and then to the city or to forego the gratification of their wants and desires, both material and social. The hours of labor have been very long in rural communities, not only for the farmer, but for the women and children as well. Little leisure has been allowed the farmer and his wife in which to develop new wants. New inventions, new methods and better opportunities to reach markets for buying and selling are decreasing the necessity for long hours and are giving the farmers better social and intellectual advantages. All forces which gradually improve the social, moral, intellectual or economic condition of the farmers as a class tend to improve their standard of living and will in turn decrease the rate of migration from country to city.



Rear Admiral
in Chief

REAR-ADMIRAL G. W. MELVILLE, U.S.N., AND APPLIED SCIENCE IN CONSTRUCTION OF THE NEW FLEET.

By the late Professor R. H. THURSTON.

AS remarked by the editor of *The Nation*, the retirement of Rear-Admiral George W. Melville merits more attention than it has received. The final withdrawal of the engineer in chief of the United States Navy is an event of importance, not only as affecting the efficiency of the naval service, the value of its fleet and the usefulness of its personnel, but also, in hardly less degree, as liable to influence the progress of applied science in that essential branch of the public service. The retiring officer has held his position, despite all political changes, for the extraordinary period of sixteen years. His fourth term expired on August 8 and, although his retiring age was attained in January, he was, under a provision of the law allowing the President that option, retained and permitted to serve out his term.

It has been during the term of service of Admiral Melville that the 'new navy' has been created and all the modern scientific methods and all the resources of the applied sciences have been availed of in its construction and operation. In this work of application of modern learning, conspiring with recent invention, Melville has been responsible for the most extensive and vitally essential innovations, those of the department of machinery of propulsion. That his administration has been attended with the highest success is sufficiently evidenced by his long retention in his office and by the unanimous agreement of our own and foreign naval experts in a high rating of our fleet. The comments of the past summer upon the occasion of the visit of the *Kearsarge* to European waters, the earlier verdict on the performance of our fleet during the Spanish-American war and particularly on the *Oregon* and her work, are illustrations of the opinions of foreign as well as of our own experts. For the whole mass of machinery with which these ships are laden, and for their performance under steam, the Chief of the Bureau of Steam Engineering of the Navy Department is ultimately responsible. Melville has carried this responsibility for sixteen years and retires with honor and appreciation by all who have officially dealt with him or who have been professionally familiar with his work. The transformation which he has witnessed and in which he has taken so large a part is only comparable to that of the original introduction of steam into the navy, and the only comparable career is that of Engineer-in-Chief Isherwood, who was similarly responsible

for the efficiency and reliability of the fleet of 1861–5 and later. But, while the latter has great interest for all as an element of the success of the government in suppressing the southern confederacy, the former is more impressive in its illustration of the application of modern science to the revolutionizing of the construction of the fleet.

The career of Admiral Melville has thus been one of peculiar interest, and I am glad to be able to review it from the standpoint of the contemporary and professional colleague, of one who entered the navy in 1861 in the same class and, with commissions of similar date, served for many years in the same corps, and later, professionally, in civil life in such capacities as permitted constant touch with the 'chief.'*

Melville's services to science as an arctic explorer antedated his appointment as chief of bureau. He was appointed 'chief' by Mr. Whitney, secretary of the navy, on August 8, 1887, and served sixteen years, the longest period of service on record for a chief of bureau. He immediately took up his task of preparing plans for the machinery of the 'new navy,' gathering about him the ablest available members of his corps. The department had meantime bought plans from foreign builders for the *Baltimore, Charleston* and *Texas;* but the work of the new bureau-chief and his corps made it quite unnecessary to experiment in that direction further. The existing fleet is, as a whole, the production of the engineers and naval architects and ordnance officers of our own Navy Department; the whole system of steam propulsion and its accessories being designed under the direction and supervision of the hero of the Lena Delta.

Among other innovations and improvements was the installation of the previously almost untried marine water-tube boiler of the general type long familiar on land. John Stevens, a century ago, asserted that the proper construction of a steam-boiler, on the score of safety, was that which divides the steam and water spaces into many small chambers, in such manner that the rupture of any one should be in minimum degree dangerous.† He invented a water-tube boiler and used it in a screw steamboat, 1804. The famous British engineer, Fairbairn, asserted the principle: A steam-boiler should be so constructed as not to be liable to explosion.‡ The modern water-tube boiler of good design combines the principle that a steam-boiler should not be liable to disruptive explosion with that which asserts that, if rupture does occur, it shall be in minimum degree dangerous. It was asserted by the writer, a generation ago, that this class must ultimately displace the older forms of 'shell-boiler' which are liable to destructive ex-

* See *Cassier's Magazine*, September, 1903, for an admirable and detailed account of the work of this distinguished officer, by his former assistant, Mr. W. M. McFarland, formerly chief engineer, U. S. N.

† 'History of the Growth of the Steam Engine.'

‡ 'Manual of the Steam-Boiler,' R. H. T.

plosion.* In fact, the list of boiler explosions, with their attendant loss of life and property, is a list of failures of the shell-boiler. Admiral Melville brought this 'new' boiler into permanent employment a hundred years after Stevens and made its value and necessity evident. The battle-ship or cruiser of to-day could not be constructed of equal speed, and equal efficiency of armor and armament, without it, and all navies are now adopting it. It gives a minimized weight and space for the unit of power, is safe against the disastrous explosions characterizing so frequently the termination of the work of the shell-boiler, and it is economical. It may be employed for pressures of any degree of intensity . The battle-ship of to-day could not attain its actual effectiveness without its employment, at least as a battery for high speeds. At cruising speeds, the older boiler is often retained; the later type being brought into operation when driving the ship up to emergency speed. The water-tube boiler requires more skill in handling than the fire-tube.

Melville introduced the triple-screw system for large ships, in which it was becoming difficult to secure safe construction of the enormous propeller-shafts demanded, and where it seemed to him desirable to secure a better hold upon the water by enlarging the area of the current utilized in propulsion. The success of the *Columbia* and the *Minneapolis,* fast cruisers, was complete, breaking the record for naval craft of large size and exceeding by a knot the speed anticipated even by their designer. He introduced the 'repair-ship,' a floating machine-shop, and the 'distilling ship,' in the war with Spain, as adjuncts to the fleet, innovations, both, of great value, often of vital importance.

In the details of his work, the chief of bureau has always exhibited the most thorough familiarity with its scientific side, and his plans have always involved the employment of every expedient known to science for promotion of efficiency. He has advocated increased thermodynamic range, higher ratios of expansion and greater piston-speeds for his engines, to give increased thermodynamic efficiency; has made effective provision against those extra-thermodynamic wastes which constitute the most serious tax upon heat utilization and has adopted every sound system of improvement known to modern science as bearing upon his work.

One of his most important movements was that in promotion of the merging of the old engineer corps of the navy into the line. The battle-ship has long been recognized as what the writer has called the

*'Report to American Institute,' 1871, *Ibidem.*

† Water-tube boilers have been built to sustain from one to two thousand pounds on the square inch. The boiler of a quadruple-expansion experimental engine constructed as 'thesis-work' in Sibley College, and the engine attached which holds the world's record for economy in its class, has been operated at above one thousand pounds.

'Engineer's War-Engine,'* simply an engine devised for destructive rather than productive purposes in contest with others of its kind, and demanding maximum possible offensive and defensive power. The naval officer, whether he will or no, must therefore be an engineer, actually, if not nominally, and whether on deck at the guns or below at the source of power. The design, the construction and the operation of this now complicated and powerful and enormously costly machine are alike tasks in engineering, and whether the mind which produces its part of the work is that of the mechanical and electrical engineer, the naval architect or the ordnance deck-officer. This fact became officially recognized when the famous 'Personnel Bill' was enacted, at the suggestion of a board on which Admiral Evans and the then Assistant Secretary of the Navy Roosevelt were strongly influential in supporting the view held by Melville. This radical change was effected and we are still awaiting the outcome.

The education of engineers at the U. S. Naval Academy, commenced nearly forty years ago, is now become an essential feature of the course for all its pupils. The 'fighting officers' of the navy have now all necessarily become engineers, and the future of that service will largely depend upon whether our ships are manned and officered by amateurs or by experts of knowledge, experience, courage and judgment. At present, the number of officers in the latter class is far too small; but this defect should remedy itself promptly. The new Naval Academy is the most complete and perfect institution of its class, perhaps of any class in the educational world, which has ever been seen or conceived; we are sending there for technical and general training as fine a body of young men as can anywhere be found, and the future history of our steam navy is likely to do no discredit to its past, either in the days of Paul Jones or in those of Farragut.

The successor of Admiral Melville is Rear-Admiral Charles W. Rae, a graduate of the Rensselaer Polytechnic Institute and an alumnus of the Naval Academy, where he graduated with the first class in engineering organized at that institution.† An officer of great ability and of high distinction, he is well fitted to continue a progress based upon modern science as well as upon advanced professional practise, and which was so admirably illustrated during Melville's period of service. The naval service has come to be perhaps the most impressive and extensive field of application of science of modern times.

* *N. A. Review*, December, 1897, 'The Engineer and his War-Engine.'

† This class of sixteen young men, coming from the colleges and technical schools of the country, was organized during the period of service of the writer at the Naval Academy and was one in which every naval officer felt peculiar interest. Its members justified every hope and expectation of the promoters of this new departure and showed admirably the value of a scientific training for their work.

SHORTER ARTICLES AND DISCUSSION.

AN UNUSUAL AURORA.

In the October number of the POPULAR SCIENCE MONTHLY, Mr. A. F. A. King has called attention to the remarkable display of aurora borealis on August 21 and has figured it as seen at York Harbor, Maine. I had the privilege of witnessing this aurora from Intervale, New Hampshire, and it corresponded very closely to the description given by Mr. King with a single exception, so remarkable that it seems to me worthy of note. At York Harbor the western half of the arch was made up of the comet-like pennants while the eastern half of the arch was continuous. This is clear, both from Mr. King's description and from the accompanying cut. As seen from Intervale this was reversed, the western half of the arch being continuous and the eastern broken. When I first saw the display, perhaps a little after half-past nine, the top of the arch was about ten degrees *south* of the zenith, and it slowly descended till about thirty degrees south. This was about half-past ten, and at this time the arch had so faded as to be hardly distinguishable..

JAS. LEWIS HOWE.

WASHINGTON AND LEE UNIVERSITY, LEXINGTON, VA.,
October 7, 1903.

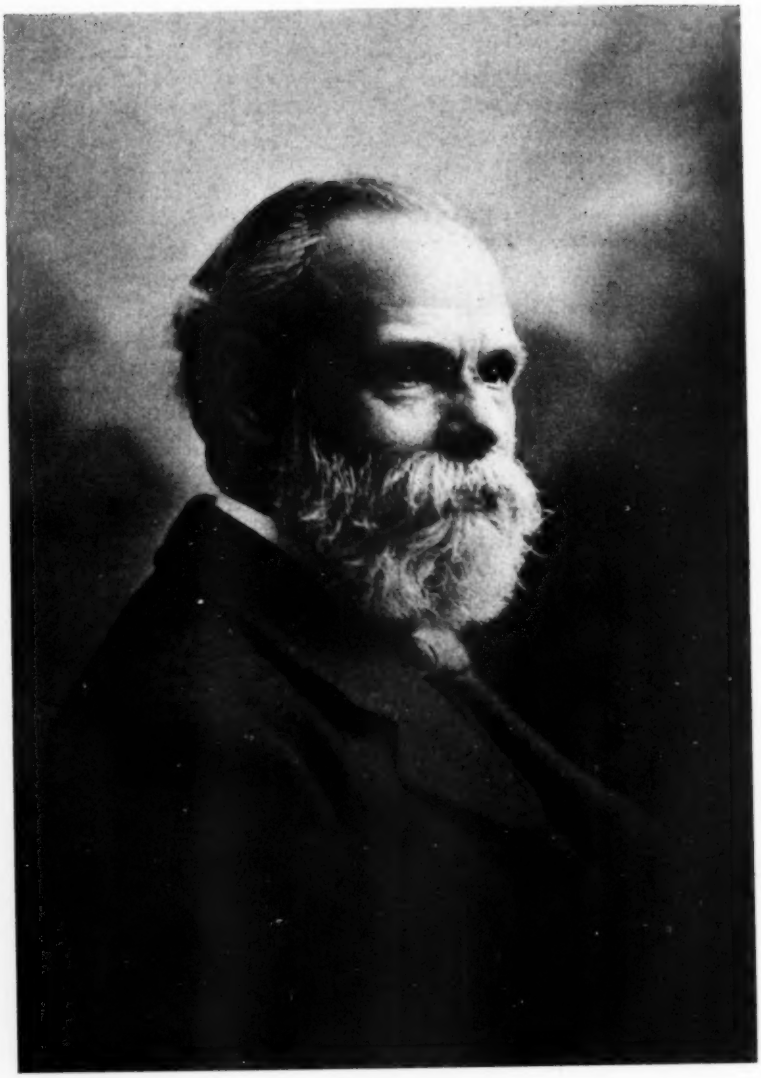
TO THE EDITOR: I was much interested in the account of the 'Auroral Arch,' given by Dr. A. F. A. King in the October number of POPULAR SCIENCE MONTHLY, owing to the facts that I observed the phenomenon and wondered what it was, and that Dr. King's observations differed somewhat from mine.

It was about 8 P.M. that I first saw the aurora. To me and others who observed it, it seemed in no way unusual save that we had not seen the 'northern lights' for several years, and we thought it was rather a poor display. No more notice was taken of it at this time. It was about nine o'clock that we were called out to see 'a peculiar appearance in the sky.' It was a band of nebulous light extending from the eastern to the western horizon, and it seemed to be about three feet wide (to me wider than the apparent diameter of the full moon). It was of nearly uniform width and intensity throughout its extent.

At nine o'clock I took the direction of the band with a pocket compass and the time by my watch. At this time the band had begun to break up at the zenith and eastern end into the 'comet-like,' slowly wavering bodies as described by Dr. King. The band continued to break from the east to a little west of the zenith until the whole eastern arc was composed of these bodies, which was at about 10 P.M., when I returned to the house. Then the western arc was intact save that it seemed to have faded somewhat.

The phenomenon as described here was seen by five others at the time and place that I saw it. I was ignorant of the nature of the display, but thought it could not be the aurora borealis, so watched the papers for the next few days to ascertain if others who might explain the phenomenon had observed it, but found nothing satisfactory until I received the October POPULAR SCIENCE MONTHLY.

W. C. KENDALL.



ROBERT HENRY THURSTON.

THE PROGRESS OF SCIENCE.

ROBERT HENRY THURSTON.

By the death of Professor R. H. Thurston education and science suffer a serious loss. His activity was wide-reaching and entirely beneficent. As a physicist he was not the peer of Gibbs and Rowland, but his work covered such a broad field and was so large in quantity that the highest exactness could scarcely be attained. His special researches in thermodynamics and their applications to the steam-engine have given him an eminent place among scientific men, while his conduct of Sibley College has proved him to be one of the educational leaders of the country. While thus carrying on the work of two men, he devoted himself unsparingly to every good cause. Innumerable demands on his time and patience were met cheerfully and helpfully. His death is a personal loss to every one who knew him, and is at the same time a public misfortune.

Thurston was born at Providence, R. I., on October 25, 1839. His death from heart disease occurred with entire suddenness on his sixty-fourth birthday, while he was awaiting guests whom he had invited to his house. He was educated at Brown University and in his father's shops. At the outbreak of the civil war he enlisted in the naval engineer corps, and served with distinction. He was on the *Monitor* in its famous engagement with the *Merrimac* and later was first assistant in charge of the ironclad *Dictator*. At the end of the war he became professor of natural philosophy in the U. S. Naval Academy, and in 1871 accepted the chair of engineering in Stevens Institute of Technology. In 1885 he accepted a professorship in mechanical engineering at Cornell University and the directorship of Sibley College. Under him the college was organized and, chiefly through his personal efforts during the past eighteen years, it has attained its present preeminent position. There are this year nearly a thousand students in the college, and its courses of study have set standards for other institutions. While thus engaged in constant teaching and arduous administrative work, Thurston was equally occupied with investigation and publication. He was the author of eleven books and of some three hundred papers. In this journal will be found many of his more popular articles, and in the present number we have the sad privilege of publishing his last paper. He was one of the editors of *Science* and of Johnson's and Appleton's Cyclopædias. He was constantly engaged on committees and commissions, and took an active part in scientific and educational societies. He was three times president of the American Association for the Advancement of Science and was first president of the American Society of Mechanical Engineers.

INTERNATIONAL EDUCATION.

Science and education have always ignored the boundaries of nations and have been important factors in promoting peace and good-will. It is a most extraordinary fact that there should have been 10,000 students from all parts of Europe at Bologne in the thirteenth century. The origin of the words 'university' and 'college' appears to have been in the separation of the students from different countries into guilds, and the organization of the *studium generale* was definitely based on the division into 'nations.' Teachers, as well as students, migrated from

Sibley College.
Cornell University.
Ithaca, N. Y.

My dear Prof. Cattell:

I note this for another purpose, but it has just occurred to me that you might have use for it; in which case, I should be quite as well satisfied.

R. H. Thurston

university to university in a manner rather difficult to reconcile with the general conception of the 'dark ages.' This movement had an important effect on the development of European civilization. It has never since been equaled, though there have been significant migrations of students, the most interesting of which from our point of view being the large number of Americans who studied in Germany during the latter half of the nineteenth century. This movement reached its culmination about 1890, when some five hundred Americans were pursuing non-professional graduate studies in German universities. But the students who went earlier to Germany had a greater effect on our educational system, as witnessed in the development of Harvard College and the establishment of the Johns Hopkins University. The movement has now become widespread, and we have some thirty universities and 5,000 students carrying on graduate work on the model of the German university. There are now a few European students attracted to our universities and at least one professor in an American institution has been offered a chair in Germany. Numerous students have come from Japan and a con-

siderable number from South America.

The American college was directly modeled on the corresponding institutions in England and Scotland, and it would probably have been an advantage, both educationally and from the point of view of international relations, if we had kept in closer touch with the British university. The will of Cecil Rhodes was an attempt to promote artificially such relations, and there is every reason to believe that it will meet with a fair degree of success. Ninety students from the United States residing at Oxford will contribute to the development of the university and will bring back to America the traditions of English education and culture. From the point of view of this journal, the entrance requirements and part of the curriculum at Oxford are a medieval survival, and the opportunities for advanced work in science are limited. But no one who has been brought intimately in contact with the Oxford life can fail to realize its charm. The influence on a few American students scattered over the whole country will surely be of advantage to them and to our relations with Great Britain. The American university presidents who have been given control of the administration of the Rhodes scholarships have decided to require residence at an American college before the student proceeds to Oxford. This is contrary to the intentions of Mr. Rhodes and appears to be scarcely justifiable from an educational point of view. For undergraduate work, Oxford possesses peculiar attractions. It would be better for a student to go through the B.A. course at Oxford and then pursue graduate studies in Germany or America, rather than to reverse the order. It may be remarked incidentally that Cambridge now offers admirable opportunities for research students in the natural and exact sciences, quite equal to those of the German universities, and that these should be more largely used than is at present the case.

A few years since America was almost outside the limits of European vision. In order to meet foreign scholars it was necessary for us to go abroad. But these conditions are changing rapidly. European men of science, and scholars singly and in groups, are continually going up and down over the land. The most eminent representatives of science and learning from Great Britain, Germany, France and other nations visit us in order to teach and to learn. Just now, for example, we are entertaining the educational commission organized by Mr. Mosely. Some thirty of the more active and eminent British educators were invited by Mr. Mosely to visit America as his guests, in order to make a study of our educational system from the primary school to the university. The commission includes scientific men, such as Professors Armstrong, Ayrton, Frankland and MacLean. A visit of this character will conduce to Anglo-American amity and the improvement of educational methods. An even more interesting event is promised for next year, when more than a hundred leading European men of science and scholars will visit the United States to take part in the Congress of Arts and Science, organized in connection with the St. Louis Exposition.

MENTAL AND MORAL HEREDITY.

THE POPULAR SCIENCE MONTHLY has had the privilege of printing two of the four Huxley Memorial Lectures, given before the Anthropological Institute of Great Britain—that on Huxley by Lord Avebury and that on the 'Improvement of the Human Breed' by Dr. Francis Galton. The latter subject is continued by the last lecture of the series given by Professor Karl Pearson, who in general is carrying forward the quantitative work on heredity which owes so much to Dr.

Galton. Professor Pearson sent circulars to a large number of teachers asking them to grade pairs of brothers and sisters for mental and moral traits, such as popularity, conscientiousness, probity, vivacity and general ability. There proved to be a remarkable fraternal resemblance, represented by a regression line of one to two, exactly the same as that found for physical traits such as the cephalic index. Professor Pearson concludes that mental and physical heredity are equally potent; mental traits are bred in the bone and are not the result of training. Great Britain could not help its position among the nations by improving its schools or by increasing technical education. The trouble is that the less able and the less energetic are more fertile than the better stocks.

Professor Pearson's figures require confirmation. The writer of this note once remarked on the resemblance of some children to their mother; the resemblance became less obvious when he was informed that she was their stepmother. The fact that two children are brothers may lead a teacher to regard them as similar in mental traits. But Professor Pearson's figures in any case appear to be misinterpreted. If the resemblance of brothers in physical and mental traits is alike, we must conclude, contrary to Professor Pearson, that the inheritance of physical and mental traits is not equal. Association and similar home life have some influence, however slight, on traits such as temper and honesty. It would be possible to argue from the figures that mental traits are not hereditary, the effects of similar environment being equal in amount to physical heredity.

SCIENTIFIC ITEMS.

THE American Association for the Advancement of Science with a large number of affiliated societies, including the American Society of Naturalists, The American Chemical Society, The American Physical Society, The Astronomical and Astrophysical Society of America, the Botanical Society of America, The American Anthropological Association, The American Psychological Association and others, meet at St. Louis in convocation week, beginning on December 28. We shall give in the next issue a forecast of the meeting, at present only calling attention to the importance of this meeting and to the admirable arrangements that have been made and urging the privilege and importance of attendance, both for professional scientific men and for those who are interested in the progress of science.

THE Lawrence Scientific School of Harvard University will receive a very large sum, said to be more than $4,000,000, from the estate of the late Gordon McKay.

PRESIDENT SCHURMAN, of Cornell University, has proposed the erection of a new building for Sibley College, in memory of the late Professor Thurston, to be known as Thurston Hall. The students of Sibley College have voted to erect a bronze memorial tablet in honor of Professor Thurston.—An obelisk of unpolished grey granite has been placed over Virchow's grave in the old Matthäi graveyard, Berlin. It bears on one side a black marble tablet, on which is inscribed 'Rudolf Virchow' and the date of his birth and death. A statue of Virchow will also be erected near the place where his scientific work was conducted.